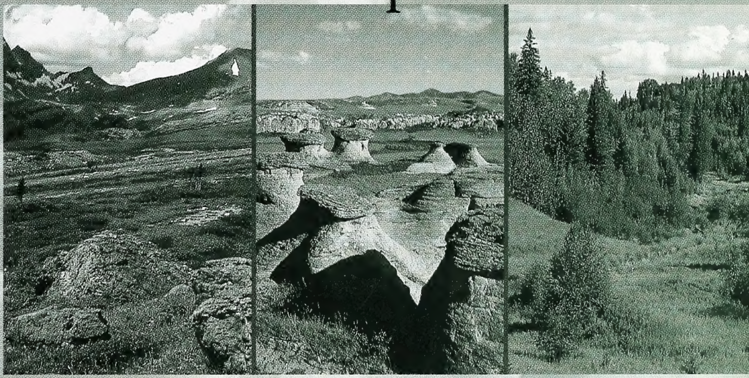
Alberta

SOE

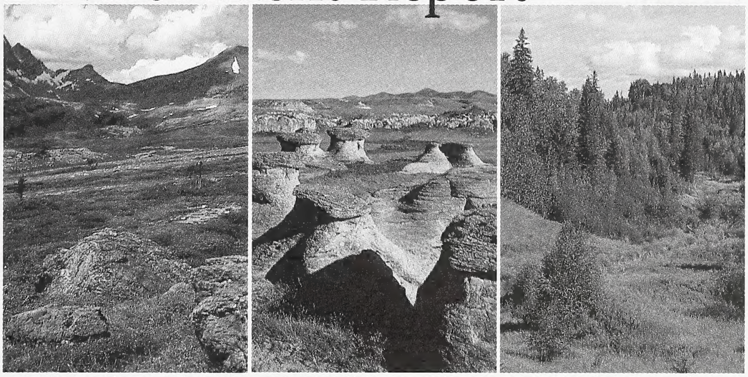
State of the Environment Report



Terrestrial Ecosystems

Alberta 1997

State of the Environment Report



Terrestrial Ecosystems

Alberta
ENVIRONMENT

For copies of this report, please contact:

Information Centre
Alberta Environment
Main Floor, Great West Life Building
9920 - 108th Street
Edmonton, Alberta, Canada T5K 2M4
Telephone: (780) 944-0313
Fax: (780) 427-4407
Email: env.infocent@gov.ab.ca

Information Centre
Alberta Environment
#100, 3115 - 12 Street NE
Calgary, Alberta, Canada T2E 7J2
Telephone: (403) 297-3362

From anywhere within Alberta, use the toll-free Alberta Government number: 310-0000.

Internet Users:
See the Alberta Environment Web site below to order this report on-line or download it.

http://www3.gov.ab.ca/env/info/infocentre/index.cfm

ISBN: 0-7785-1925-2 (printed version)
ISBN: 0-7785-1926-0 (on-line version)
Printed: November 2001

Publication Number: T/634

Table of Contents

List of Figures and Tables

List of Figures

List of Tables

Preface

The Department of Environment is committed to inform Albertans about the environment and produces many reports on the status of Alberta's environmental resources. This ensures accountability and gives Albertans important information for their own consideration and use. There is also a legislative basis for state of the environment reporting. Alberta's *Environmental Protection and Enhancement Act* states that the Minister shall report annually on the state of the Alberta environment.

Nationally, the Canadian Council of Ministers of the Environment have promoted a common approach to State of the Environment reporting.

The purpose of State of the Environment (SOE) reporting is to provide timely, accurate, and accessible information on ecosystem conditions and trends, their significance and societal responses, emphasizing the use of indicators.

This information will increase public understanding and education. It assists priority-setting and decision-making about matters related to the environment by providing objective and scientifically valid information. The information also establishes linkages between environmental conditions and socio-economic factors, reflecting the importance of the relationship that exists between humans and the environment.

Education about the environment is an important goal of SOE reporting. In addition to facts and figures about the state of Alberta's environment, this report features background history and science to help the reader interpret the information presented.

SOE reports focus on three areas of interest: environmental conditions, pressures on the environment, and responses to these conditions and pressures. They make extensive use of environmental indicators, key measurements that can be used to monitor, describe, and interpret change. Indicators can help us answer questions such as:

- What environmental trends are occurring?
- Why are they significant?
- What actions are being taken?

They can also help us better manage our environment by setting targets and tracking progress toward them. We can see what works best and adjust our programs where needed.

A comprehensive State of the Environment Report will be published periodically, covering all aspects of the environment. The first of these reports was published in 1994. Since then, SOE reports have focussed on particular themes, such as waste management and aquatic ecosystems. In addition to these reports, shorter fact sheets on specific issues or programs are published as part of the SOE series.

The theme of this report is terrestrial ecosystems.

Acknowledgements

Early drafts of this report were researched and written primarily by Richard Chabaylo of RMC Environmental Services. Staff in Alberta Environment, Alberta Sustainable Resource Development, Alberta Agriculture, Food and Rural Development, and Alberta Health and Wellness provided much of the information and reviewed many drafts. Betty Hope, Duke Hunter, and Ken Sloman, all of Alberta Environment, contributed substantially to the preparation of figures and tables. Brian Free provided overall project management.

Readers are invited to provide comments on this year's report or any aspect of SOE reporting to Alberta Environment at the address below. A Reader Survey form is enclosed at the end of this report. Your feedback would be greatly appreciated.

Alberta Environment
Public Education and Outreach Branch
Main Floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta
T5K 2J6

1.0 Introduction

1.1 What Are Terrestrial Ecosystems?

The root words of ecosystem are *eco*, a derivative of the Greek term for house or home, and *system*, which refers to the relationships and connections between the ecosystem's biological and physical parts. Every ecosystem is made up of a set of physical components (soils, minerals, water, etc.) and a set of populations of different species. Ecosystems vary in size and composition and have functional relationships within and between systems. The living and non-living elements of an ecosystem are connected through the transfer of energy and the cycling of chemical elements (for example, water, carbon, oxygen, and nitrogen). A terrestrial ecosystem can be defined as follows:

> *An assemblage of plants, animals and other organisms together with the non-living components of the upland environment, interacting among themselves as natural communities and functioning as an interdependent unit.*

An ecosystem consists of a variety of different elements that function together as a unit, affecting— and affected by— each other. In this system, it is impossible to modify one element without affecting the others in some way. This is one of the most important lessons that the science of ecology has taught us: everything is connected to everything else (Odum 1989).

Ecology also teaches another important principle: terrestrial ecosystems are dynamic — the processes that form and maintain them are always changing. Some changes occur very slowly, such as the process of soil formation on Precambrian shield rock. Changes can also be sudden and catastrophic: fire, flooding, and damage by insects and disease. These natural disturbances are important in maintaining the essential components and natural diversity within terrestrial ecosystems.

1.2 Why Focus on Terrestrial Ecosystems?

Terrestrial, or non-aquatic, ecosystems occupy approximately 82 percent of the area of Alberta (541 385 square kilometres) in the form of dominant landscapes such as prairie grasslands, parklands, mountain ranges and northern forests. These landscapes provide Albertans with an abundance of renewable and non-renewable natural resources which have allowed our economy to prosper — soils for growing crops and raising livestock, forests for producing wood and paper products, and large reserves of coal, oil and natural gas for producing energy and petroleum products. Indeed, the strength of the provincial economy is based heavily on these terrestrial resources. Albertans also place a high priority on the non-consumptive use of our natural environment such as outdoor activities that contribute to tourism, social well-being, and the quality of life.

In 1996, goods and services produced from the consumption and export of natural resource-based products contributed $20.3 billion, or 24 percent, toward the provincial gross domestic product (Alberta Economic Development and Tourism 1996). This includes fishing and trapping; forestry and the manufacturing of wood and paper products; agriculture; mining and energy sectors; refined petroleum and coal products; and the natural resource royalties paid by industry. This heavy reliance on our natural resources also accounts for a substantial proportion of employment in Alberta.

In the past, we viewed these natural resources as limitless, and often took for granted the natural beauty and ecological diversity of our province. However, times have changed, and so have our perceptions. Today most people recognize that our environment is not something external to our lives. We have come to realize, and are continually learning, that people are part of the environment. We rely on the clean air, soil, water and many plant and animal products of terrestrial ecosystems for our basic human needs: food, shelter, energy and economic prosperity. We also discharge wastes that become part of the chemical cycles critical to the function of ecosystems.

Population is one of the most important factors that affects the relationship of a species and its environment. Alberta's human population has grown rapidly this century: from 73 000 in 1901 to 2 744 700 in 1996. It will likely continue to grow for some time. Alberta's population density has increased accordingly: from 0.1 persons per square kilometre to 4.2 persons per square kilometre, respectively.

Our impact on the environment depends not only on our overall numbers, but also on our population distribution (city versus rural), levels of consumption of energy and materials, and technology. The combination of technology and population growth can place ever-increasing pressure on terrestrial ecosystems.

1.3 Scope and Organization of the Report

This report describes the state of terrestrial ecosystems in Alberta by first presenting a province-wide perspective, followed by a more-focused natural regions perspective. The information in this report reflects data up to 1997.

Provincial Perspective - the majority of the information needed to discuss the state of the environment is collected, organized, and presented at the provincial level, primarily within well-defined land use categories and economic sectors.

Natural Regions Perspective - recognizing that many of the necessary data are not organized by natural region, this perspective presents some important issues related to the state of the environment within each natural region.

Focus issues and *case studies* will appear in the report to illustrate important issues or specific points. Focus Issues discuss topics of special interest. Case Studies highlight and discuss more specific examples or circumstances related to state of the environment in Alberta.

Throughout the report, words that are explained in the Glossary are bold and italicized when they first appear.

Chapter 2 provides an overview of terrestrial ecosystems in Alberta. It briefly describes Alberta's geography, climate, the processes that shaped its landscape, and the soils, plants and animals of the province.

Chapter 3 gives a provincial perspective on the major land uses, citing present conditions, agents of change, actions and future directions. It includes major subsections on agricultural lands, forested lands, non-renewable resources, urban areas and transportation, and recreation and protected areas.

Chapter 4 describes the major natural regions of Alberta and discusses some of the more important environmental issues related to each of these terrestrial ecosystems.

Chapter 5 presents some overall conclusions and future trends regarding the state of Alberta's terrestrial ecosystems.

2.0
Overview of Terrestrial Ecosystems in Alberta

Geography

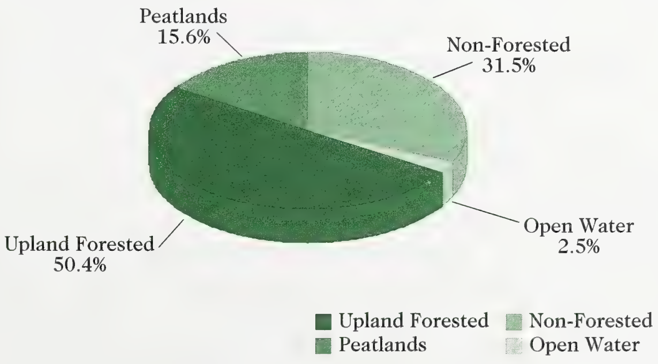
Alberta covers 661 185 square kilometres — 7.2 percent of the land mass of Canada. The area covered by open water, such as lakes and slough/marsh wetlands, is approximately 16 800 square kilometres (2.5 percent of the province). Wetland ecosystems in Alberta include an additional 103 000 square kilometres (15.6 percent) of peatlands, the majority of which occur in the forested areas of the province (Vitt *et al.* 1997). Peatlands are wetlands that accumulate peat when water tables stabilize. In Alberta, these ecosystems are often covered by a wide variety of plant life including mosses, lichens, sedges, shrubs, willows and several tree species.

Terrestrial ecosystems dominate the Alberta landscape — 541 385 square kilometres (81.9 percent). Non-forested lands, primarily grasslands and parklands used for agriculture and settlement, occupy approximately 208 000 square kilometres (31.5 percent). Forested lands cover approximately 351 000 square kilometres, dominated by upland forests found in the Rocky Mountains, foothills, parklands and northern boreal areas, as well as lowland forests found on the vast peatlands in the north.

Roughly one-half of the southwest quarter of the province is dominated by mountains and foothills — peaks of the Rocky Mountains in Alberta range from 2130 to 3747 metres in elevation. The remainder of the province — approximately 90 percent of the land area — forms part of the interior plain of North America. In Alberta, this area includes the grasslands in the south, and the heavily forested areas and peatlands in the north. The mountains and plains are striking reminders of the geologic forces that shaped the landscape we see today.

Figure 2.1

Proportion of Terrestrial and Aquatic Ecosystems in Alberta



Source: Alberta Environment and Vitt *et.al.* 1997

Climate

Alberta has what is known as a continental climate. It is characterized by vivid seasonal contrasts—long, cold winters balanced by warm summers and a high number of sunny days, no matter what the season. Arctic air masses in the winter can produce prolonged periods of cold, with very low temperatures, particularly in non-mountainous regions. In winter, temperature decreases as one moves north (higher latitude) or away from the mountains. In summer, the highest elevations have the lowest temperatures, but the effect of latitude on temperature is reduced.

In July, the average temperature varies from 20°C in the south to 14°C in the north. In January, the average temperature varies from -24°C in the north to -9°C in the southwest. The recorded extremes in temperature were a high temperature of 43.3°C (Bassano, 1931) and a low temperature of -61.1°C (Fort Vermilion, 1911). The range of average temperature across the province in winter is greater than in summer because of the reduced heating from the sun at northern latitudes. Although cold air covers the entire province in winter, it is frequently replaced in the southwest by mild weather often associated with strong westerly winds, called chinooks, funnelling through mountain passes from the Pacific Ocean.

Alberta has a semi-arid climate because the annual precipitation is generally less than the water evaporated. The semi-arid southern grasslands have the lowest precipitation in the province and relatively hot summers. The parklands and boreal forest normally experience greater amounts of precipitation than the grasslands. Average annual precipitation ranges from 271 millimetres in Empress to 1072 millimetres in Waterton Lakes National Park. Average annual precipitation in Edmonton is 466 millimetres, and in Calgary 399 millimetres. In general, annual precipitation is more variable in southern Alberta and the Peace River area than in other parts of the province.

Forces That Shaped the Landscape

The combined effects of movements in the Earth's crust, climate, water and ice acting over vast periods of geologic time have carved the landscape of Alberta. In the Cretaceous Period (100 million to 66 million years ago), shallow seas advanced and retreated many times during a period of active continental drift, depositing layer upon layer of sand and silt. These layers became compressed and hardened into calcareous deposits of sandstone and shale that occur as bedrock formations throughout most of the province. Coal deposits formed from compressed vegetation and pockets of oil trapped in porous rock and sands from the remains of abundant aquatic life. Fossilized remains of plants and animals provide a permanent record of terrestrial ecosystems from this period.

With the uplift of land in the more recent Cenozoic era (65 million years ago to present), the seas retreated. The tropical climate became temperate, due to the overall increase in land surface elevation, and a rich mammalian fauna (animal life) developed. Massive uplift and westward movements of the earth's crust into what is now British Columbia formed the Rocky Mountains. The resulting folded and broken rock extended far eastward, as sandstone and shale was pushed into great ripples, forming the foothills. By the end of the first part of the Cenozoic era, known as the Tertiary Period, the bedrock geology of the province was established, and with it many of the topographic features we see today. The rise of the Rocky Mountains created a rain shadow, effectively ringing moisture from the maritime air masses moving eastward from the Pacific Ocean.

Following the Tertiary Period, the Quaternary Period (1.8 million years ago to present) brought a cooling of the climate and four glaciations, or ice ages, to North America. In the last great glaciation, called the Wisconsin, sheets of ice up to 1600 metres thick began to grind across Alberta from the north and west. Eventually, all of Alberta was covered with ice except for high mountain peaks and parts of the Cypress Hills and Porcupine Hills. As the last ice sheets melted and retreated, they left a blanket of glacial till up to 100 metres thick over most of Alberta east of the mountains. Most life was pushed south by the advancing ice sheet, but returned as the ice retreated. Glaciation refined the appearance of the landscape and created many surface features on which the bulk of the present-day vegetation exists. All modern flora and fauna immigrated into the province subsequent to the last glaciation.

The interaction of climate, land and water is a process that continues even today. Climatic factors such as precipitation, temperature, and wind play an important role in determining the major vegetation types covering the provincial landscape. Grasslands typify the windy, semi-arid prairies in the south. Here, the availability of moisture is the single most important factor limiting tree growth, and treed habitats are largely confined to river valley floodplains. Continuous forests dominate the western and northern parts of Alberta where there is more moisture to support tree growth.

2.1 Natural Regions of Alberta

Three major climatic regimes occur in Alberta: Grassland, Cordilleran (mountain range), and Boreal (northern) (Strong and Leggat 1992). The interaction of these three important climatic regimes influences temperature and moisture conditions, which is reflected in the vegetation patterns and other associated physical attributes that we see in the province. These patterns and landscapes help define Alberta's natural regions and their terrestrial ecosystems. There are six well-defined natural regions in Alberta. Within these regions are a total of 20 subregions (Figure 2.2).

Figure 2.2

Natural Regions and Subregions of Alberta

Boreal Forest
- Central Mixedwood 1
- Dry Mixedwood 2
- Wetland Mixedwood 3
- Sub-Arctic 4
- Peace River Lowlands 5
- Boreal Highlands 6

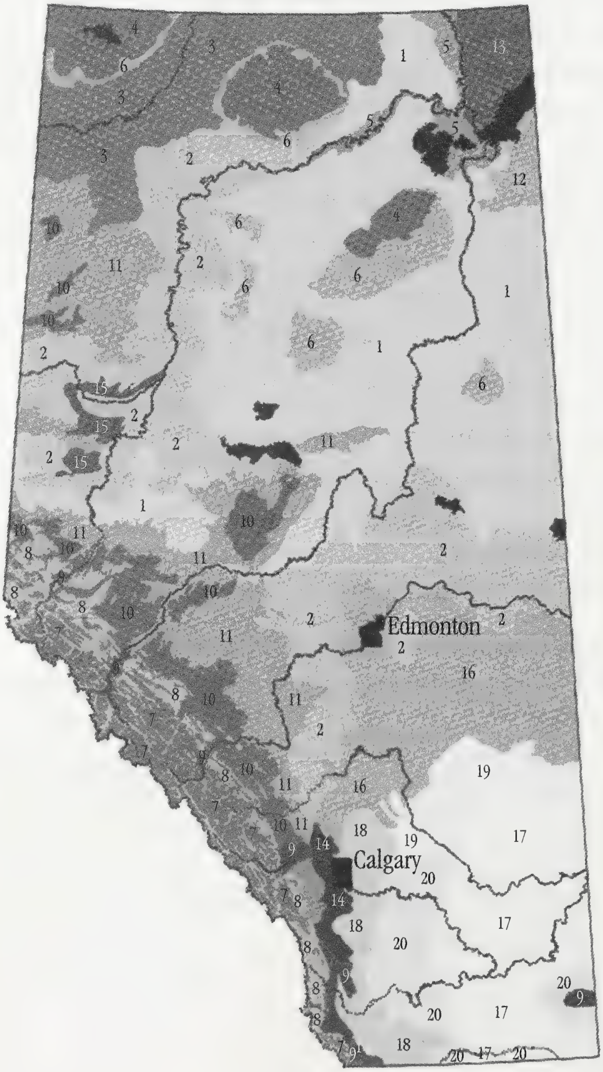
Rocky Mountain
- Alpine 7
- Subalpine 8
- Montane 9

Foothills
- Upper Foothills 10
- Lower Foothills 11

Canadian Shield
- Athabasca Plain 12
- Kazan Upland 13

Parkland
- Foothills Parkland 14
- Peace River Parkland 15
- Central Parkland 16

Grassland
- Dry Mixedgrass 17
- Foothills Fescue 18
- Northern Fescue 19
- Mixedgrass 20



The Natural Regions land classification system used in Alberta emphasizes overall landscape pattern. In some cases this pattern reflects climate, in others the predominance of geological factors or soil conditions (Achuff 1994). The system's primary purpose is to provide a common classification system that accounts for the entire range of natural landscape or ecosystem diversity in Alberta. It is used by a number of Alberta government agencies, non-government conservation groups, and industrial interests (for example, forest industry for forest management planning).

The natural region classification system is based primarily on terrestrial factors. Although aquatic ecosystems will not be discussed in detail within this report, reference will be made to them where it is necessary to understand their connection to terrestrial ecosystems. For more information about Alberta's aquatic ecosystems, the reader should see the 1996 Alberta State of the Environment Report. A more detailed physical description of Alberta's Natural Regions, as well as a discussion of important environmental issues pertinent to each, is provided in Chapter 4.

2.2 Soils

Pedologists, or soil scientists, define soil in general terms this way: the naturally occurring unattached mineral or organic material at the earth's surface that is capable of supporting plant growth. Soil is a complex biological system that has developed in Alberta since the last glaciation 10 000 years ago. Soil formation is a continuous process, but it is also extremely slow. The productive portion of the soil is the topsoil, a relatively thin veneer of well-structured soil containing essential nutrients, microbes, and organic matter needed to support vigorous plant life. It can take more than 100 years for one centimetre of topsoil to form. This thin layer is the foundation of all terrestrial life. Soils also help to determine how the land is used.

Organic Matter

Organic matter is living or dead plant and animal material. When organic matter decomposes in soil, it becomes humus. It increases aeration and water-holding capacity, reduces the soil's susceptibility to erosion and supplies necessary nutrients. Organic matter also improves the structure of the soil.

The composition of soil can vary widely, but it is usually a mixture of mineral particles (sand, silt and clay), organic remains in various stages of decomposition, water, air and a wide variety of living organisms. The community of organisms that live below the surface is vital to the condition of soil. These organisms (for example, beetles, worms, mites, fungi, algae, and bacteria) break down and mix the organic matter in the soil. They also help aerate the soil as they move through it. These organisms are important nutrient recyclers, decomposing organic matter and returning its nutrients to the soil.

2.2.1 Soil Forming Processes

Soil development involves many physical, chemical, and biological factors acting over time on materials such as rock, gravel and sand. This process is influenced by topographic features, like degree of slope, and the presence and actions of water. Climatic factors such as precipitation, relative humidity, temperature and solar radiation also influence soil formation. For example, cooler temperatures are less ideal for soil formation because they slow the rate at which humus accumulates and decomposes. That is why there are thinner topsoils and fewer available plant nutrients in the soils of the mountains and in northern Alberta. Soils that receive little moisture, such as sandy areas, can only support specially adapted plants.

The combined effects of the various factors that influence soil formation produce many different types of soils. Soils formed on shale, sandstone, or ground-up rocks and minerals left by glaciers are called mineral soils. Soils developed in organic materials like peat are called organic soils.

Two general processes dominate mineral soil development in Alberta: acid leaching and calcification.

Acid Leaching

Acid leaching is the soil-forming process in areas where trees predominate. The organic residues (leaves and needles) that accumulate on the soil surface decompose to form soluble (leachable) products. These products include organic acids that remove mineral nutrients from the surface soil layer and carry the finer clay particles down into the subsoil. As a result, the surface soil tends to have few nutrients and are coarse in texture, while the subsoil becomes enriched with clay and less permeable to water and roots. The scientific name for such soils is Luvisolic soils. These soils dominate the boreal forest and foothills natural regions in Alberta.

Calcification

Calcification occurs in areas where grass vegetation predominates. Grasses return basic materials such as calcium and magnesium to the upper soil layers, thereby maintaining a non-acid, nutrient-rich environment. In this non-acid environment, plant remains decompose to insoluble (non-leachable) organic compounds, which accumulate in the surface layer of soil as humus. In addition, fine clay particles do not leach into the subsoil. The resulting soils are referred to as Chernozemic soils. These types of soils dominate the grassland and parkland natural regions of Alberta.

2.2.2 Classification of Alberta Soils

Soil scientists have developed a system of soil classification that is used Canada-wide, including Alberta (Soil Classification Working Group 1998). This system has organized the knowledge of soils in a reasonable and practical way. The classes (or taxa) of soils are based on soil properties. It is possible to map the kinds of soils in an area, which can provide a basis for evaluating the area for a variety of potential uses. Nine of the ten major soil units present in Alberta are shown in Figure 2.3. The tenth soil unit, Vertisols, which was recently added to the classification system, is found mainly in the Drumheller basin but covers too small an area to be shown in the diagram.

A Description of Soil Types in Alberta

Chernozemic soils develop on a wide variety of parent materials underneath grasslands in well drained to imperfectly drained sites. Brown Chernozemic soils are found where there are short grasses and very dry conditions; Black Chernozemic soils have a higher organic content and occur in less dry areas. Chernozemic soils are usually excellent for agricultural production. Black soils constitute only 16 percent of all soils in Alberta, but they account for one-third of the land used for agriculture.

Luvisolic soils develop on a wide variety of parent materials underneath mixed ***deciduous-coniferous*** forests. They cover 52 percent of the province and are generally found in imperfectly drained to moderately well-drained sites. Most luvisols tend to be less productive for agricultural purposes because of their lower organic content and shorter growing season.

Organic soils occur in poorly drained areas with saturated conditions. They form by the accumulation of dead organic materials such as sedge or moss peat. Organic Cryosols are organic soils with permafrost within one metre of the surface.

Brunisolic soils develop on imperfectly drained to well-drained sites on various types of parent materials, but often on sand and gravel. The develop under various forest vegetation, mainly coniferous. Brunisols tend to be rather thin, and intermediate in character between luvisols and regosols.

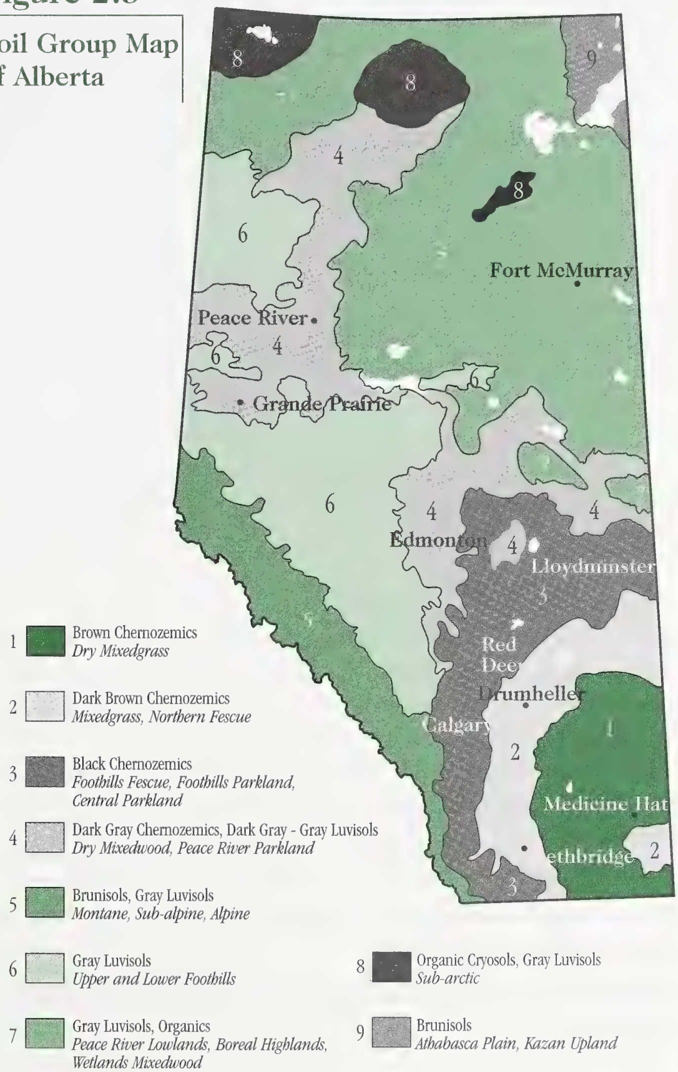
Gleysolic soils develop under wet conditions and may have a thin surface layer of undecomposed peat.

Solonetzic soils are characterized by high levels of sodium that creates a dense, clay-enriched horizon or "hardpan" below the surface layer. This often reduces crop production by restricting the plants' root depth.

Regosolic soils lack recognizable soil horizons. They are generally found on recently deposited materials under a wide range of vegetation, climate and drainage conditions.

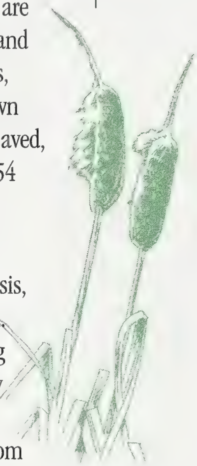
Figure 2.3

Soil Group Map of Alberta



2.3 Flora

If soils are the foundation of terrestrial ecosystems, then plants are the backbone to which the form and function of all terrestrial ecosystems are connected. Alberta's ecosystems support one of the most diverse floras in Canada. There are 3675 species of ***vascular plants***, ***bryophytes*** (mosses and liverworts) and fungi documented in Alberta. Of these, 1949 are classified as vascular plants, while mosses, lichens and fungi amount to 1726 species. A further breakdown reveals 28 species of trees; 1510 species of shrubs, ferns and ***forbs*** (broad-leaved, non-woody plants); 411 graminoids (grasses and sedges), 627 bryophytes; 454 fungi; and 645 lichens (Alberta Natural Heritage Information Centre 1997).



Plants are the life support systems of terrestrial environments. The most important ecological role of plants is air purification. Through photosynthesis, green plants absorb carbon dioxide from the atmosphere and release oxygen. Plants are the primary producers at the base of terrestrial food chains. Using carbon from the air, and elements from the soil, plants provide the necessary proteins and other nutrients for ***herbivores***, which are in turn eaten by ***carnivores***. In addition to being a source of food, plant communities (from open grassland to ***mixedwood*** forest) form the variety of habitats used by virtually all terrestrial animal species. Some types of plants, including many trees, provide nutrients and a stable home for a variety of highly specialized, parasitic plant species. Plants also protect the soils on which they grow and use their roots and above-ground cover to reduce the effects of wind and water erosion.

2.3.1 Species of Concern

A total of 535 vascular plants and 268 mosses have been identified as species of concern in Alberta (Alberta Natural Heritage Information Centre). Because many of these species are considered rare in the province, their status has been evaluated and is being monitored by the Alberta Natural Heritage Information Centre. (A rare plant is one with only a small population in the province.) Generally, there are four different categories of rare plants (See sidebar). For most of Alberta's rare plants, we are only beginning to gather the required information to determine which species are threatened or endangered.

Many of the species identified as rare in Alberta are found over a very restricted range. They include the following:

Extreme northeast (shield and sand dune) - Indian Tansy, Sand Chickweed, Stemless Lady's-slipper;

Cordilleran (mountain meadows) - Freedman's Poppy, Alpine Poppy, Oregon Saxifrage;

Southeast - Upland Evening-primrose, Western Spiderwort;

Southwest (montane) - Big Sagebrush, Hare-footed Locoweed, Western Blue Flag, Yellow Paintbrush (Packer and Bradley 1984).

What is a rare plant?

1. Species such as some of Alberta's native orchids which are widespread but never abundant. There may be many reasons for this. Often it is because the species has special habitat requirements. Only about one percent of Alberta's rare species fall into this category.
2. Species that are widespread but which have reached the edge of their range in Alberta and so have only a small population here. These are called peripheral species. About 84 percent of our rare plants fall into this category.
3. Species found in localized, widely scattered populations. These are called disjunct species. They may occur as restricted, separate populations throughout their range, or they may be widespread in part of their range, but with some isolated disjunct populations .
4. Species that occur only in a limited geographic area. These are called endemic species. Although there may be large numbers of them where they do occur, because their range is so restricted they are usually considered rare. About five percent of our rare plants are endemic.

What is a threatened or endangered plant?

An endangered plant is one in danger of becoming extinct in all or part of its range. A threatened plant is one likely to become endangered in the near future. To know whether a plant species is threatened or endangered requires extensive knowledge about that species' habitat needs, its present population size, factors controlling its population size and possible threats.

Why conserve rare plant species?

Although extinction is natural, the rapid rate of extinctions caused by people since the industrial revolution can lead to unpredictable destabilization of ecosystems. Fundamentally, we need to preserve the biological diversity of plants for ecosystem stability and resilience. Plants support all ecosystems, form the base of all food chains, and support other human needs. For instance, about 25 to 40 percent of modern drugs are based on substances found in plants, but only two percent of plant species have ever been tested. Finally, the loss of a single plant species represents a loss of biological diversity, and often results in the loss of other species dependent on that plant, such as certain insects or birds.

Source: Alberta Forestry, Lands and Wildlife. 1993

2.3.2 Introduced Plant Species

About 15 percent (292) of Alberta's 1949 vascular plants have been introduced from outside of Alberta (Alberta Natural Heritage Information Centre). This includes many common pest species that we refer to as "weeds". A recent national survey of botanical experts identified a number of non-native, invasive plant species of special concern. In Alberta, the invasive species of greatest concern include leafy spurge, Canada thistle, knapweeds, sweet clovers, nodding thistle, quack grass, smooth brome grass, crested wheat grass, Kentucky blue grass and purple loosestrife (Haber 1996). These species are typically widespread and spreading and, under certain conditions, can flourish by out-competing the native flora. Attempts to control the spread of non-native species have proven expensive and often ineffective.

Some of the most successful invasive plants of native prairies in the grassland and parkland natural regions are introduced grasses. These grasses have been widely planted for forage, reclamation and erosion control. Species of concern include smooth brome grass, crested wheat grass, Kentucky blue grass, quack grass and timothy. Smooth brome grass is one of the most widely planted forage grasses in western Canada (Haber 1996). Its aggressive spread by seed and rhizomes has allowed smooth brome to proliferate in some areas, with widespread negative impacts on the flora of native grasslands. Kentucky blue grass is invasive and even dominant in overgrazed ***fescue*** prairie. Crested wheat grass is a species of special concern in natural grasslands because it has been widely planted for forage production. Yellow and white sweet clovers are more than just roadside weeds in Alberta, and tend to be very widespread and invasive where sites have been disturbed previously. Canada thistle is also widespread and spreading, especially in areas disturbed by factors such as overgrazing.

The wonder of grasses

Grasses are one of the most versatile and useful of plant families. Cultivated varieties of grasses provide us with enormous quantities of food. The cultivation of cereal crops is the major livelihood for a large portion of the human population. The grass family includes sugar cane and cereals such as wheat, barley, oats, rye, corn and rice. These plants are either eaten as grain or in primary food ingredients such as flour, sugar and edible oils.

Grains can also be brewed into alcohol: barley for beers and whiskeys, rye into whiskey, rice into sake and molasses from sugar cane into rum. A more potent type of alcohol, called ethanol, is brewed from grain for use as an additive in gasoline to produce a cleaner burning fuel.

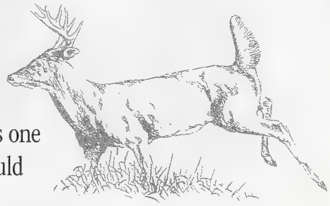
Grasses also provide the principle forage for livestock, and are used as turf for lawns, parks, athletic fields and golf courses. In many countries, they provide the materials for weaving, thatch, adobe and bamboo structures. Many species of wildlife, from large grazing mammals to mice and waterfowl, also depend on grass and grassland habitats for food, shelter and the completion of their life cycle.

(adapted from Johnson *et al.* 1995)

2.4 Terrestrial Fauna

2.4.1 Wildlife

The terrestrial fauna of Alberta comes in an amazing variety of types, shapes and sizes. Alberta has a total of 450 species of animals that we normally refer to as "wildlife", excluding insects, spiders and other invertebrates. Ten of these species are amphibians, eight are reptiles, 92 are mammals and 370 are birds. The animals included in this list of wildlife are all those species and subspecies native to Alberta, as well as those that were introduced into the province long ago. Introduced animals are limited to a total of six birds (gray partridge, ring-necked pheasant, Merriam's turkey, rock dove, European starling, and house sparrow) and two mammals (house mouse, gray squirrel). However, not all wildlife species can be classified as strictly terrestrial. For example, animals such as beaver, muskrat and river otter are referred to as semi-aquatic, spending much of their life in water. As well, the wandering garter snake is one of the most aquatic of garter snakes and would be inappropriately referred to as terrestrial.



Albertans have long enjoyed a wide variety and abundance of terrestrial wildlife. However, many Albertans probably underestimate the economic, recreational and aesthetic value of the many types of wildlife in the province. In 1991, Albertans spent $834.7 million on wildlife-related recreational activities (Filion et al. 1994). Of this total, $156 million (19 percent) was spent on hunting, and more than $431 million (52 percent) was spent on non-consumptive trips or outings (watching, feeding, photographing or studying wildlife). The remainder was spent on other activities, including contributions to wildlife organizations, natural area preservation, residential activities, and incidental encounters with wildlife. Overall, these wildlife expenditures contributed $932.6 million to the provincial gross domestic product (GDP) and supported 17 152 jobs.

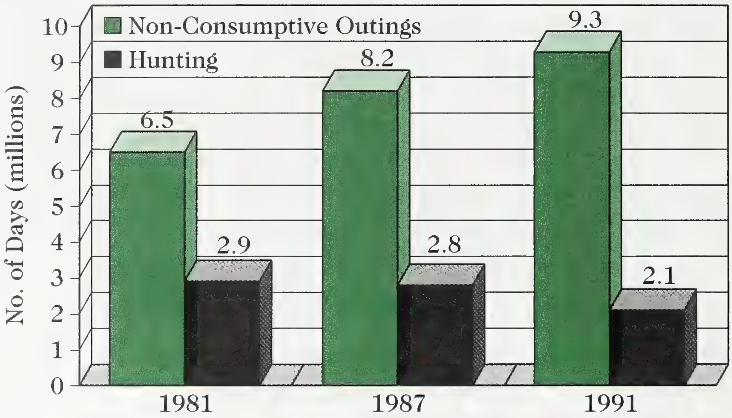
In 1991, 1.8 million Alberta residents aged 15 and older participated in a wide range of wildlife-related activities. An estimated 1.4 million, participated in "residential activities" (feeding, watching, photographing, providing bird houses, and so on), 383 000 took at least one primary non-consumptive trip or outing, 977 000 encountered wildlife incidentally during other trips or outings, and 134 000 Alberta residents hunted wildlife (Filion *et al.* 1993).

A comparison of the 1991 survey results with those from similar surveys in 1981 and 1987 shows that the number of people participating in wildlife-related

activities as a whole increased by 17.9 percent over the decade, whereas Alberta's population grew by 16.2 percent over the same time period. The total number of days spent on all wildlife-related activities increased by about 50 percent between 1981 and 1991, from 89 million to 133.5 million (Filion et al. 1993). The number of days spent by participants on primary non-consumptive trips or outings increased steadily during this period, whereas the number of days of hunting participation declined (Figure 2.4).

Figure 2.4

Trends in the Number of Days that Albertans Engaged in Wildlife-Related Outings



Source: Filion *et al.* 1993

The ecological value of terrestrial wildlife is also very important. For example, species such as the Richardson's ground squirrel (prairie gopher) form a critical link in the food chains of grassland and parkland ecosystems. Although considered a pest by many, ground squirrels are food for a number of predators, and their burrows are used by a wide variety of animals as homes or cover. Burrowing owls are dependent on the existing holes made by burrow-digging mammals (badger, Richardson's ground squirrel), and have received considerable attention in recent years as a species in jeopardy. Larger carnivores, such as wolves and cougars, prey on large herbivorous animals (e.g., moose and deer), thereby keeping their numbers from increasing to the extent that they over-exploit their food supply. Beavers alter watercourses and build dams, often improving breeding conditions for woodland-nesting waterfowl and creating over-wintering habitat for fish. Most migrant songbirds that nest in our forests during the summer feed on insects, of which many are harmful forest pests. Woodpeckers excavate cavities in trees for nesting, which in turn are used by a number of other cavity-dwelling birds and mammals. Hawks and owls are important predators of small rodents, thereby helping to reduce rodent damage on agricultural lands. The list of ecological benefits of wildlife goes on and on.

Some terrestrial animals, particularly those considered to be at risk, are valuable as indicator species. An indicator species can be one that is particularly sensitive to the effects of development and human activities. Population or habitat declines of these species can indicate environmental stress on them, as well as on the ecosystem to which they belong. Indicator species are often used to help determine the environmental impacts of large-scale development activities, or for evaluating the ecological sensitivity of certain areas. Typically, indicator species are those that have some significant importance, such as traditional use (for example, moose), economic value (for example, furbearing animals), and special status as species at risk (for example, northern leopard frog). Indicator species are also useful for monitoring ecological integrity and overall biodiversity. For example, black-backed woodpeckers are good indicators of burned-over forest with a lot of dead ***snags*** for nesting and feeding.

2.4.2 Insects

No discussion of Alberta's terrestrial fauna is complete without some mention of one of the most important animal groups — insects and arachnids (which includes spiders). It is fair to say that we know little about these creatures. Entomologists, or insect scientists, regularly discover previously unknown species of these invertebrate animals. And although between 8000 and 9000 different kinds have been collected in Alberta, it is estimated that the actual number of species occurring in the province is between 20 000 and 40 000.

Many of us might marvel at insects when we see a beautifully coloured damselfly or butterfly fluttering nearby. We give considerable respect to a bumblebee buzzing from one flower to the next. Some people despise insects, for example when mosquitoes, flies, and wasps disrupt our backyard barbecue. However, the vast majority of us have one thing in common when it comes to insects — we fail to recognize their real significance and ecological importance.

The ecological value of insects and their role in maintaining biological diversity cannot be overstated. Insects are instrumental in the propagation of many plant species — pollinating approximately three-quarters of all flowering plants in Alberta. Insects often form a key link in both terrestrial and aquatic food chains. Many Alberta mammals are herbivorous, feeding on many plant species pollinated by insects. Of the more than 250 species of birds that nest in Alberta during the summer, likely 95 percent use insects to some degree in their diet, particularly as high protein food for their growing young. Some species of trout in mountain and foothill streams, highly sought after by anglers, feed almost exclusively on adult insects and their aquatic larvae. Insects also help in decomposition and soil formation by eating dead plant and animal material and returning nutrients to the soil. And spiders prey on a variety of insects, many of which are pests in gardens and crops.

2.4.3 Wildlife Species of Concern

A wildlife status evaluation system used in Alberta separated wildlife species into five categories, or lists. In the broad sense, the categories were defined at three levels of concern: "at risk" (RED list), "may be at risk" (BLUE list), "not at risk" (YELLOW and GREEN lists) and "unknown" (STATUS UNDETERMINED). The word risk is used to indicate the risk of extirpation (removal) within the province. The evaluation was based on five criteria: abundance, breeding distribution, habitat integrity, population trend and national/international status (Alberta Environmental Protection 1996a).

In 1996, twenty-nine species of terrestrial wildlife were considered to be of concern in Alberta (RED and BLUE list species): five amphibians, three reptiles, 13 birds and eight mammals (Table 2.1). Two species have been ***extirpated*** (Greater prairie chicken, black-footed ferret), one is extinct (passenger pigeon), and one may be extinct (eskimo curlew).

Note: Since 1996, the wildlife status evaluation system was revised. Contact Alberta Fish and Wildlife for more recent information.

Table 2.1

Terrestrial wildlife of concern in Alberta, 1996

	STATUS		
GROUP	RED LIST	BLUE LIST	EXTIRPATED*
Amphibians	northern leopard frog great plains toad Canadian toad	spotted frog plains spadefoot toad	
Reptiles		prairie rattlesnake short-horned lizard** western hognose snake	
Birds	burrowing owl** peregrine falcon** piping plover** whooping crane**	bay-breasted warbler black-throated green warbler Cape May warbler ferruginous hawk** long-billed curlew** sage grouse** short-eared owl** Sprague's pipit trumpeter swan	greater prairie chicken
Mammals	swift fox** wood bison**	grizzly bear** northern long-eared bat Ord's kangaroo rat** red-tailed chipmunk woodland caribou** wolverine**	black-footed ferret

* Extirpated is defined as a species no longer existing in the wild in Alberta, but occurring elsewhere.

** Indicates that the species also has designated status with the Committee on the Status of Endangered Wildlife in Canada.

Typically, there are many factors influencing the status and existence of a species at risk. A common link for many is large-scale habitat loss or alteration from human activities. Other contributing factors include limited availability of very specific habitat types needed by some species, human disturbance and encroachment in key habitat areas, widespread use of chemical pesticides, and a naturally low reproductive rate for some species.

Wildlife populations can change rapidly, particularly in areas affected by intensive land-use practices. There is an ongoing need to monitor these changes to ensure populations remain viable, and to anticipate the effects of changing habitat conditions. The Alberta Government is committed to evaluating the status of wildlife on a continuing basis.

Categories for wildlife species "of concern" in Alberta

Red List

Current knowledge suggests that these species are at risk. Populations of these species have declined, or are believed to have declined, to non-viable levels, or show a rate of decrease indicating that they are at immediate risk of declining to non-viable levels in Alberta.

Blue List

Current knowledge suggests that these species may be at risk, although the threats they face are less immediate. This list includes species that are particularly vulnerable because of non-cyclical declines in populations or habitat, or reductions in provincial distribution.

Case Study: Peregrine Falcon - A Success Story

Although never abundant, the peregrine falcon was relatively common in Alberta prior to the 1950s, with an estimated nesting population of at least 100 pairs (Rowell and Stepnisky 1997). Its historic range covered the length of the province. The falcon prefers to nest along the major river valleys.

During the 1950s-60s, the indiscriminate use of certain pesticides, most notably DDT, resulted in a dramatic decline of the peregrine falcon across North America. By 1973, only three pairs of peregrines were known to exist in Alberta — all in the northeast corner of the province (Rowell and Stepnisky 1997).

Thanks to joint federal-provincial efforts, captive breeding and reintroduction programs have successfully reintroduced peregrine falcons into their historic Alberta breeding range and increased the population size. A captive breeding and reintroduction program was initiated with the help of the Canadian Wildlife Service at the raptor breeding facility near Wainwright, Alberta. The Southern Alberta Peregrine Falcon Reintroduction Project began in 1992. Between 1992 and 1996, 223 peregrines, raised in captivity at the Wainwright facility, were released at sites located along southern Alberta river valleys. In 1997, there were 19 pairs of peregrine falcons established in southern Alberta. Today the current provincial breeding population is estimated at about 50 pairs.

The use of DDT and many other harmful organochlorine pesticides is banned in North America, but the agricultural and industrial application of these chemicals still occurs in many South American countries where Alberta's peregrines overwinter. Contaminant residues in eggs, young and adults of falcons and other birds of prey are good indicators for some aspects of environmental health. Although breeding peregrines and their eggs still contain detectable levels of DDE

(a metabolite of DDT), the levels appear to be decreasing in Alberta. Levels of DDE and PCBs (polychlorinated biphenyls) in egg contents showed significant decreases over the last three decades (Court *et al.* 1996).

Court et al. (1996) predicted a strong recovery of the peregrine falcon over the next decade. However, the monitoring of peregrine populations and the pollutants that affect them remains a priority in Alberta.

2.5 Action for Important/Sensitive Species

2.5.1 Status of Alberta Wildlife Report

As interest in wildlife has grown and broadened, so has our understanding of the value and need to maintain undisrupted and diverse ecosystems. We now know it is essential to understand the biological status of all wildlife. The status of wildlife is one of the performance measures that Alberta Environment uses to determine the effectiveness of its policies and programs. The department's Status of Alberta Wildlife report is updated and revised every five years (Alberta Environmental Protection 1996a). The report is designed to improve information and awareness on the current status of wildlife. It is a vital reference for anyone interested in wildlife conservation and management.

Ranking species through a general status assessment is just the first step in the process of effectively managing and conserving Alberta's biological diversity. For species of concern (Blue and Red list), the next step involves preparing detailed status reports to determine population levels and the factors influencing them. Twelve detailed status reports have been completed to date — northern leopard frog, prairie rattlesnake, eastern short-horned lizard, sage grouse, peregrine falcon, burrowing owl, piping plover, Sprague's pipit, northern long-eared bat, Ord's kangaroo rat, swift fox and wolverine. In the third step, species that appear to be in serious trouble are formally designated as an endangered species under the *Wildlife Act*. Step four is to develop and implement formal recovery plans. The fifth and final step involves ongoing management activities to prevent other sensitive species (designated Yellow List species) from meeting the same fate.

2.5.2 Biodiversity/Species Observation Database

The Biodiversity/Species Observation Database is a data management system designed to assist with the status evaluation and conservation of wildlife species in Alberta. This database makes it easier to store and retrieve wildlife observation

data, including non-biological features that are critical to their conservation (for example, snake hibernacula, roosts and nurseries for bats). The system uses state-of-the-art data management software to store information on any wildlife species and can provide reports for Alberta Environment staff to use when planning for land-use activities that may affect sensitive species. The system can also map species observations for any particular area and enables the exchange of observation data with other agencies and organizations.

Biodiversity

Biological diversity, or biodiversity, refers to the assortment of life on earth. It is the variability among all plants, animals and microorganisms and the ecological complexes of which they are part. It includes diversity within species, between species, and among ecosystems.

Why is biodiversity important?

Human beings depend on biodiversity. It is vital for the natural ecological processes upon which all life depends. We also use many species of plants and animals for food, clothing, raw materials and medicines. Biological resources from the wealth of the earth's plants, animals and microorganisms support human livelihoods, and make it possible to adapt to changing needs and environments. Governments, industries, development agencies, and the general public are increasingly aware that successful development depends on the maintenance of biodiversity. Many scientists rate the worldwide decline in biodiversity as one of the most important global environmental threats.

Dynamics of Biodiversity

Changes in plant and animal populations are normal within certain limits. Biological diversity is affected by natural events (for example, volcanoes, fire, wind, insects, and disease) and by human activity. Human activities affecting biodiversity include landscape alteration; pollution of soil, water and atmosphere; harvesting of trees, fish, and other species; replacing native plant communities with domesticated agricultural crops and the introduction of pests and weeds into local ecosystems. Some of these activities increase biodiversity, but others threaten native species.

Conserving and protecting Alberta's biodiversity

The Government of Alberta has many programs and policies aimed at maintaining biodiversity within this natural range of variability. Generally, the conservation of biodiversity involves better integrating human activities with natural processes and natural changes in landscapes.

Alberta is committed to the objectives of the Canadian Biodiversity Strategy. Some specific conservation efforts include:

- Completion of a network of protected areas through the Special Places program,
- Conservation policies, like the Alberta Forest Legacy, Prairie Conservation Action Plan, and Fish Conservation Strategy,
- Implementation of adaptive, ecological management for renewable natural resources,
- Species management plans and recovery plans,
- Long-term monitoring,
- Encouraging private stewardship, and
- Research and education.

It should be noted that the data included in the Biodiversity/Species Observation Database are observational only. Accurate identifications are essential particularly for plants and invertebrates, but also for examinations of geographic variation in vertebrates. This requires knowledgeable curators and an extensive specimen-based database like the one at the Provincial Museum of Alberta.

2.5.3 Amendments to the Wildlife Act

The *Wildlife Act* and its regulations provide legal protection for threatened and endangered species in Alberta. These species are protected from killing, hunting or harassment, and their nests or dens are also protected from disturbance. Violators are subject to penalties of up to $100,000 in fines and six months in prison. In 1997, the *Wildlife Act* was amended, complete with new regulations, to provide increased protection for threatened and endangered species in the province. The legislation is consistent with the National Accord for the Protection of Species at Risk. Legislation and law will be used where necessary to facilitate the protection and recovery of threatened and endangered species

Instead of considering only traditional "wildlife" species (reptiles, amphibians, birds, mammals), the new legislation has broadened the definition of wildlife. The *Wildlife Act* now protects animals, fish, invertebrates (insects), plants, algae and fungi if they are designated as threatened or endangered. The legislation provides for the establishment of an Endangered Species Conservation Committee. This committee advises the Minister of Environment about the designation of threatened/endangered species, and endangered species and biodiversity conservation. The Act also provides for the assessment of threatened/endangered species by an independent scientific committee.

2.5.4 Endangered Species Recovery

In the past few years, Alberta Fish and Wildlife has produced a number of status reports, management plans and recovery strategies for Alberta species known to be at risk. These species include rare ones with low reproductive rates, those that depend on vulnerable habitats, and those species that are particularly sensitive to human activities. National recovery plans, developed with Alberta involvement, have been completed for the swift fox, peregrine falcon, burrowing owl, whooping crane, ferruginous hawk, piping plover, loggerhead shrike, Baird's sparrow and greater prairie chicken. In addition, recovery plans are being prepared for the wood bison, black-footed ferret, sage grouse, eskimo curlew and mountain plover.

The Alberta goal is to restore all species classified as threatened or endangered to viable population levels. An ongoing challenge is to prevent other species of concern from ever becoming threatened or endangered. Alberta's efforts are fully integrated with national initiatives under the Committee on the Status of

Endangered Wildlife in Canada (COSEWIC) and the Recovery of Nationally Endangered Wildlife (RENEW) processes. The amended *Wildlife Act* provides for formal recovery plans for those species legally designated as either threatened or endangered in Alberta. These plans may identify population goals, critical habitats and strategies to help populations to recover.

2.5.5 Management Plans for Game Species

Increasing demands on wildlife resources, and the lands and habitat that support them, prompted Alberta Environment to develop management plans for each of the major game species. The primary purpose of these management plans is to provide a historical and current perspective on a species' status and objectives to ensure the species is managed sustainably.

In principle, the management plans are a blueprint for maintaining game populations within the bounds of ecosystem and social parameters that exist in the province. Each plan defines population goals and management guidelines. The guidelines are based on relevant regions or ecosystems, within a context of provincial populations. The plans recognize the multitude of land uses and land users, the public demand for the resource, and access to it. The plans also promote the wildlife resource's compatibility with other land uses by identifying potential conflicts and providing strategies for minimizing them.

To date, management plans have been completed for eight game species: white-tailed deer, mule deer, pronghorn antelope, bighorn sheep, grizzly bear, black bear, wolf and cougar. Management plans for mountain goat, moose and elk are being developed. Species management plans will be updated periodically as required.

Further Reading about Alberta's Flora and Fauna

Argus, G.W. and K.M. Pryer. 1990. *Rare vascular plants in Canada - our natural heritage.* Canadian Museum of Nature, Ottawa. 1991 pp. + maps.

Wallis, C. C.E. Bradley, M. Fairbarns and V. Loewen. 1987. *The rare flora of Alberta.* Volumes 1, 2, 3 and 4. Prepared for Public Lands Division, Alberta Forestry, Lands and Wildlife, Edmonton.

Semenchuk, G.P. [ed.]. 1993. *The atlas of breeding birds of Alberta.* Federation of Alberta Naturalists, Edmonton. 391 pp.

Smith, H. 1993. *Alberta mammals: an atlas and guide.* Provincial Museum of Alberta, Edmonton.

Bird, C.D., G.J. Hilchie, N.C. Kondla, E.M. Pike, and F.A. Sperling. 1995. *Alberta butterflies.* Provincial Museum of Alberta, Edmonton.

Committee on the Status of Endangered Wildlife in Canada. 1996. *Canadian species at risk.* Ottawa.

Queen's Printer for Alberta. *Wildlife Act.*

3.0 *Land Uses*

Today we can see unmistakable signs of some form of land use in every part of the province.

On this land Albertans have created a successful economy based on natural resource industries grounded in terrestrial ecosystems. However, the demands for land use continue to rise. Albertans must continue to find ways of managing their land base to maintain the capability of the land for today and the future.

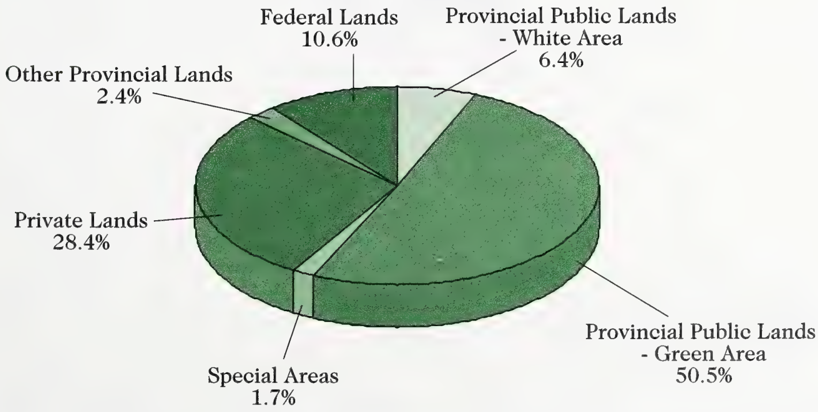
Most of the lands within Alberta fall under public ownership, including various kinds of federal and provincial holdings (Figure 3.1). Federal lands include national parks, Canadian Forces Bases and training areas, and Indian Reserves. Provincial public lands include provincial parks, Special Areas, Metis Settlements and many public lands used under special dispositions for agriculture, forestry, recreation and other uses.

Special Areas

The "Special Areas" is an area in central- southeastern Alberta that was created in the late 1930's after much of the area was devastated by drought and soil erosion. A special form of municipal government, spearheaded by an elected Special Areas Board, provides municipal services to the area.

Figure 3.1

Land Ownership Categories



Source: Alberta Agriculture, Food and Rural Development

The Alberta Government is committed to sustainable development. This means that natural resources shall be managed in a manner that addresses their interdependence and recognizes that the use of one resource can affect other users and other resources. Through integrated resource management, there will be better coordination among government departments and agencies responsible for natural resource management. Land uses will be managed to better protect the environment and sustain economic and social benefits for Albertans.

The diversity of landscapes in Alberta supports a broad range of land use activities. This chapter of the report explores these land uses on a province-wide scale. Subsections highlight the major land uses in Alberta — those related to agricultural lands, forested lands, non-renewable resources (energy reserves and mineral resources), urban development, transportation and utility corridors, recreation, tourism and protected areas. For each major land use, there is a discussion of present conditions, role in the provincial economy (where applicable), agents of change, and measures taken to reverse unfavourable trends.

"Agents of change" is used here to describe two basic categories of environmental change: natural change, and human-caused change. In terms of their effects, such changes—or "disturbances"—can be rapid or gradual, obvious or subtle, and of variable duration. For example, a well known *natural* disturbance in forested landscapes is fire. An example of a *human* disturbance is a large urban centre, which creates environmental stress regardless of the terrestrial ecosystem in which it is located.

Figure 3.2

Public Lands: Green and White Areas of Alberta

Source: Alberta Environment

Alberta's Public Lands

For the purpose of managing Alberta's public lands, the province has been divided into two regions. The White Area refers to the settled regions where agriculture is the most significant land use, and includes the grasslands and parklands of central and southern regions, and the Peace Country in the north (Figure 3.2). The Green Area refers to the mainly public, forested lands of northern Alberta and the Eastern Slopes that were originally withdrawn from settlement. Both the Green and White areas contain public lands that are managed by the Alberta government for a variety of uses and benefits*.

Forestry is a major land use in the Green Area with almost 18 million hectares covered by Forest Management Agreements alone. Of the 4.2 million hectares of public land in the White Area, over 2.6 million hectares are under some kind of land use contract (disposition). Agriculture is an important use of these lands, primarily for livestock, but also for cultivation of some lands. Almost 2.5 million hectares are under some form of livestock grazing disposition and it is estimated that one-quarter of Alberta's beef cattle rely on summer grazing on public lands under grazing lease.

A wide variety of non-agricultural uses also occur on White Area public land, sometimes sharing the same land that is under grazing disposition. These uses range from pipeline rights-of-way, surface leases for minerals and aggregates and other industrial uses, to roadways and recreational uses.

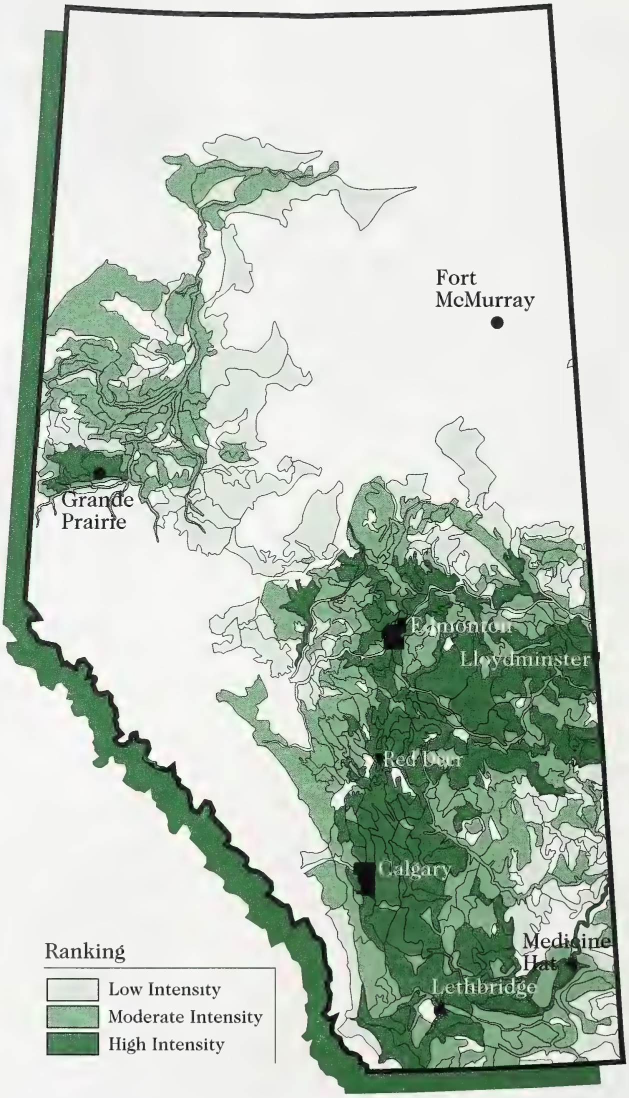
* Responsibility for managing public lands has been transferred to the Department of Sustainable Resource Development.

3.1 Agricultural Lands

Today, as in the past, agricultural activity remains one of the dominant land uses in Alberta. Most of Alberta's crop and livestock production takes place in the prairies, which is mostly semi-arid grasslands and sub-humid aspen parkland. The brown, dark brown and black soils found in this region account for about three-quarters of the agricultural land base in Alberta. The black soils have the highest organic content and most favorable moisture conditions for growing crops. Large farming areas also occur in the southern part of the boreal forest, and in the Peace River region of northern Alberta. The dark grey soils here are less productive. The cooler climate in this region results in a limited growing season for many annual crops, but the long summer daylight hours allow certain crops to reach maturity (Figure 3.3).

Figure 3.3

Agricultural Intensity in Alberta



Soil Landscape Units ranked according to agricultural intensity (chemical+fertilizer expenditures+animal density units)

Source: Canada-Alberta Environmentally Sustainable Agriculture Agreement. Water Quality Committee 1998.

3.1.1 Present Conditions

The past century has seen the growth of a dynamic agricultural industry in Alberta. In that time, the industry has undergone significant changes. The number of farms has decreased, but the average farm size has increased by more than two-fold (Table 3.1). (This long-term trend recently reversed with an increase in the number of small specialty farms.) The area of the agricultural land base has also changed, increasing by 33 percent from 15.8 million hectares to 21.0 million hectares since 1931. This land base represents about one-third the area of the province.

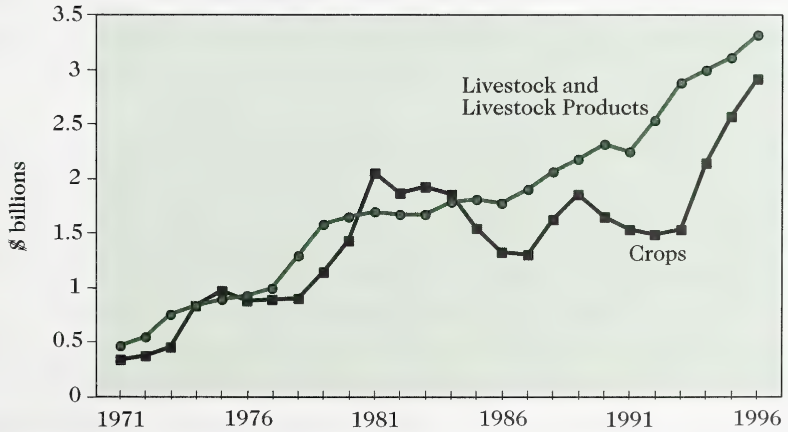
Technological advances have been a major factor influencing these trends. Mechanized farming and modern methods such as the use of chemical fertilizers and pesticides have enabled fewer people to do more work and produce more than was previously possible. Economic factors have favoured large-scale operations. Of the total farmland in 1996, approximately 52 percent was cultivated, and 41 percent was pasture (Statistics Canada 1997a). The remainder had various uses (farmyards, wetlands, woodlots, etc).

Primary agriculture is Alberta's largest renewable resource-based industry. Alberta accounts for 25 percent of annual Canadian agricultural production with only nine per cent of Canada's population. In 1996, primary agriculture generated a record $6.4 billion in farm cash receipts, representing 22.6 percent of Canada's primary agricultural output. Typically, annual sales of products are about evenly balanced between crops and livestock (Figure 3.4). Agricultural processing, including food and beverage processing industries, is Alberta's largest manufacturing sector. Shipments set a record for output in 1996 at $6.6 billion in sales.

Combined, the agricultural production and processing sectors were the second largest employer in the province in 1996. Employment in agriculture and agri-food averaged 116 200 jobs during 1996. Alberta's agri-food industry maintains a very low level of unemployment compared to any of the other major industries in Alberta. The agri-food industry contributes roughly five percent of the provincial gross domestic product for Alberta (Alberta Agriculture, Food and Rural Development 1997).

Figure 3.4

Alberta Farm Cash Receipts, 1971 to 1996



Source: Statistics Canada 1997 and
Alberta Agriculture, Food and Rural Development 1995

Table 3.1

Demographic trends of farming in Alberta, 1931 to 1996

	Year							
	1931	1941	1951	1961	1971	1981	1991	1996
Total Farm population	375 097	383 964	345 222	287 814	237 924	195 284	176 935	188 510
% of provincial population	51.3	48.2	36.7	21.6	14.6	8.7	7.0	7.0
Number of farms	97 408	99 732	84 315	73 212	62 702	58 056	57 245	59 007
Average farm size (ha)	162	176	213	261	320	329	363	357
Total area of farmland (ha)	15 773 776	17 513 962	17 992 715	19 113 314	20 034 803	20 207 204	20 811 003	21 027 457

Source: Statistics Canada, 1996 Census of Agriculture

Crops

A wide variety of crops are grown throughout Alberta, influenced largely by market conditions and regional growing conditions such as heat, moisture and number of frost-free days. The four major crop categories are cereals, oilseeds, specialty crops and forages. Cereal crops include spring- and fall-seeded wheat, malt and feed barley, oats, rye, durum, and triticale (a hybrid of wheat and rye). The principal oilseed crops in Alberta are canola and flax. Specialty crops include field peas, mustard, lentils, dry bean, fababean, safflower, sunflower, canaryseed, herbs and spices, sugar beets, potatoes, corn and other vegetables grown for commercial production. Forage crops include alfalfa, brome grass, timothy, wheatgrasses, clover and wildryes. The most important crop types in Alberta, based on production values and sales, are wheat, barley, canola and ***tame hay***.

Moisture is the limiting factor to crop growth in the warmer, drier brown and dark brown soil zones of southern Alberta. Irrigation is one of the primary methods of improving agricultural productivity and diversifying the range of crops grown in this region. Irrigated crops account for about 12 percent of Alberta's agricultural production, even though irrigated land constitutes only 4.5 percent of the total cultivated area. Irrigation greatly increases yields over what would be expected without the additional moisture. Irrigation also enables the growing of crops such as sugar beets and soft spring wheat, which could not survive on the amount of moisture available on dryland farms in Alberta.

In addition to these economic benefits, the irrigation infrastructure in southern Alberta supplies water to 48 towns and villages, hundreds of country residences, farmsteads, industrial users and wetlands projects. Most of the water-based recreation and much of the wetland habitat in southern Alberta is supported by the irrigation district infrastructure. There are 607 000 hectares of land serviced for irrigation in Alberta by 13 irrigation districts and private irrigators.

Livestock

Livestock production is a major part of the province's agricultural industry. The main types of livestock produced are cattle (beef and dairy), hogs, poultry (eggs and meat), sheep (wool and meat), and horses (recreation, sport, meat and pregnant mare urine). Recently, farmers have shown a growing interest in specialty livestock. A small number of farms raise animals such as alpaca, angora goats, llama, bison, elk, wild boar, and even emu and ostrich. Specialty livestock are raised for breeding stock, recreation, meat and other products.

Revenue from livestock production has slightly exceeded revenue from crops in every year since 1985 (Figure 3.4). This trend is largely due to growth in the hog and cattle industries. In 1996, Alberta accounted for 42 percent of Canada's beef cattle inventory - a total of 5.9 million cows and calves (beef and dairy). Almost 59 percent of all Canadian cattle and calf sales in 1996 originated from Alberta, a new industry high. The total number of pigs remained virtually unchanged at 2.0 million between 1991 and 1996. Over the same period, the total number of sheep and lambs decreased 15 percent to 260 000 (Statistics Canada 1997a).

Because the major component of hog feed is barley, the principal hog production region corresponds with the best barley producing area: the black soil zone from just north of Edmonton to just south of Red Deer. The second major hog production region is around Lethbridge. More than 60 percent of Alberta's hog production comes from nine percent of the hog operations. These larger producers feature highly mechanized operations and a small land base.

Although the provincial beef industry traditionally produced cattle in the ranching areas of southern Alberta, cow and calf production is now predominantly north of Calgary, and expanding in the province. Areas in west central, east central and northeast Alberta have concentrations of cows equal to some of the large ranches in southwest Alberta. These three areas are in the black and dark brown soil zones, ideal areas for feed production (forages and grain), and close to available markets. Beef operations numbered 24 718 in the 1996 census of agriculture, accounting for 45 percent of all farms in Alberta.

The cow/calf sector has changed significantly over the last decade, especially in herd size. In 1989, average herd size was between 78 to 177 animals. By 1993, average herd size was larger than 272 animals. Most feedlots are in southern Alberta, but there has been recent growth in the number of feedlots in central Alberta. Feedlots can range in size from 500 to over 30 000 animals.

The main resources needed for beef production are forage and cereal crops, and water. Grazing occurs on both tame pasture and native range. Feed supplies come from silage (cereal or grass) and/or feed grains (wheat and barley). Water is supplied from dugouts, lakes, rivers or groundwater. Growth in herd size and

Pregnant Mare Urine

Urine from pregnant horses is sold to the pharmaceutical industry to manufacture estrogen therapy products

numbers can increase the demands on the environment if the required land and water resources, and the manure generated, are not managed responsibly.

Rangelands and pasturelands are an essential resource for livestock grazing. At present, these lands provide about 25 percent of the forage required by beef cattle in Alberta. Alberta grazing lands are extensive and diverse. Their area has been estimated at more than 8.5 million hectares (Statistics Canada 1997a). This area is distributed among five of Alberta's natural regions: grassland and parkland (containing 72 percent of the grazing lands), boreal forest, foothills, and montane areas in southern Alberta.

A large portion of Alberta's rangeland is located on public lands. In 1997, it was estimated that more than 2.5 million hectares of public lands were under some form of grazing lease, licence or permit. The majority of the area, 93 percent, is located on public land in the White Area. This total has remained relatively unchanged over the past ten years. There are 32 Provincial Grazing Reserves encompassing a total of 291 000 hectares of public land in the province.

Rangelands and Pasture

Rangelands - natural grasslands of native plant communities where the principal form of management is controlled grazing. Total area in Alberta is 6.6 million hectares.

Pasture - grassland that has been seeded with tame grass, fertilized, drained or otherwise enhanced for production. Total area in Alberta is 1.9 million hectares.

3.1.2 Agents of Change

Agents of change on agricultural lands are from both natural and human sources. The natural sources are soil and climate (for example, erosion, moisture availability, soil fertility). Human-caused pressures on agricultural lands and surrounding environments typically stem from farm management practices related to crop and grazing land use. Natural agents of change and farm management practices are interconnected, and sometimes difficult to distinguish. This section describes some of the natural factors and the human-caused pressures on agricultural lands in Alberta. Farm management practices that can minimize negative impacts are discussed in section 3.1.3.

Soil Erosion

Erosion is the removal of soil particles by the forces of wind and water. Wind and water erosion can threaten the long-term productivity of soils through the loss of valuable, nutrient-rich topsoil. Erosion occurs naturally, but some land use practices can accelerate its rate. Soil erosion is estimated to reduce annual net profits by an average of $12 per cropped hectare (Prairie Farm Rehabilitation Administration 1990). Where soils are deep enough, topsoil can be rebuilt, but only at a very slow rate (generally much slower than the rate of soil erosion).

Erosion by Wind

The Dust Bowl of the 1930s was a vivid example of wind erosion - unprotected topsoil blackened the skies, and drifted into ditches and along fence lines. The result was unproductive fields and ruined crops. Since then, the agriculture industry has made great progress in controlling and preventing wind erosion.

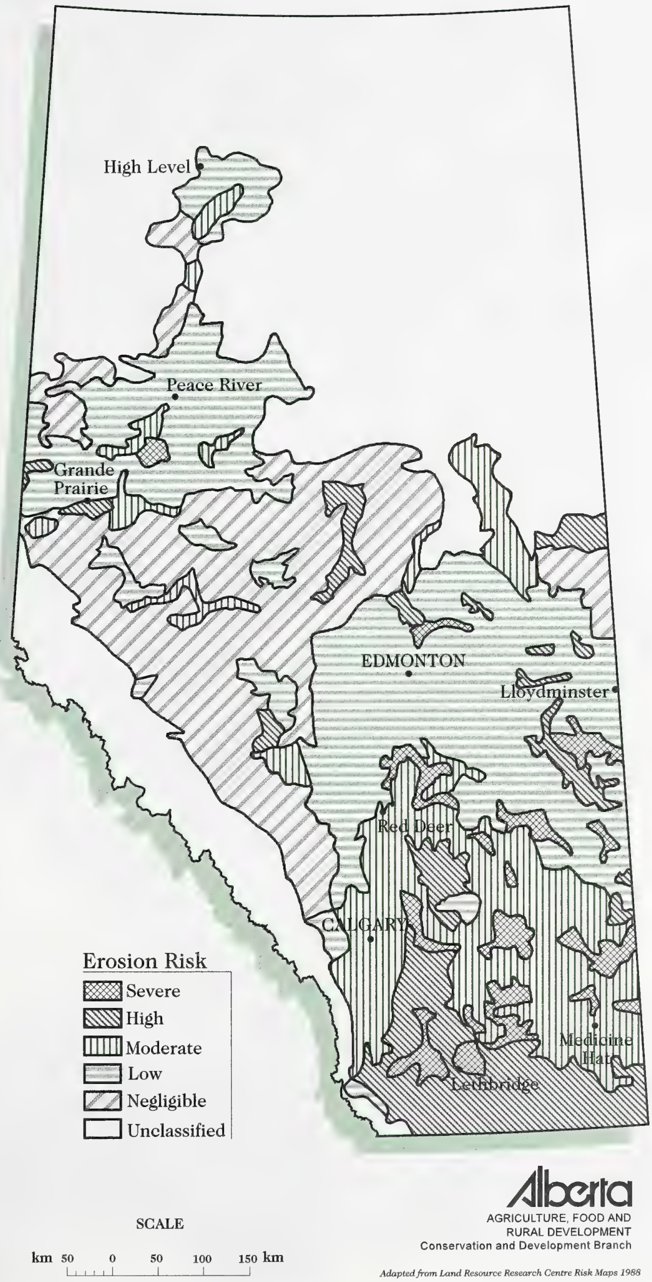
Figure 3.5

Wind Erosion Risk of Alberta Soils

Nonetheless, agricultural land across Alberta is still subject to periods of drought and strong winds, particularly on open prairies.

During the recent drought of the 1980's, wind erosion damaged an estimated 900 000 hectares of agricultural soils in Alberta (Timmermans and Larney 1996). Strong and sustained winds along with dry, bare soils contributed to serious topsoil loss. Valuable nutrients were also removed with the topsoil, reducing the soil's ability to produce crops. Coarser materials left behind by the wind, a reduced topsoil layer, a decrease in the root zone depth and in the soil's water holding capacity - all contributed to further reducing soil quality and productivity.

Factors that increase the risk of wind erosion include a sparse or absent plant cover, large fields and strong winds, and a loose, dry, smooth soil surface. Soil texture and structure also affect wind erosion risk. Loams, clay loams and silt loams generally resist wind erosion better because the soil clumps are harder to break down. Soils with more organic matter are more resistant to wind erosion because organic matter helps to hold clumps together. Figure 3.5 shows which areas of Alberta are prone to wind erosion.



Alberta AGRICULTURE, FOOD AND RURAL DEVELOPMENT
Conservation and Development Branch

Adapted from Land Resource Research Centre Risk Maps 1988

Erosion by Water

Most soil loss due to water occurs because of high runoff events, such as heavy rainstorms. Soils are subject to water erosion throughout Alberta. Extreme rainstorms have led to serious soil loss events on farmland from Medicine Hat to Fort Vermilion. Measurements on a continuously cropped farm field near Tofield reported soil losses as high as 10 tonnes per hectare for the summer of 1996 as a result of a number of moderate rainstorms.

Fields with poor water infiltration as a result of clay-enriched, compacted, or hardened subsoil, are at increased risk of water erosion. These soils rapidly reach the point where they are unable to absorb more water. Any additional rainfall is then forced to move as surface runoff, carrying away the topsoil. Some soils are more prone to erosion for other reasons, such as steep slope. Protecting soil through good agricultural land management is the single most important factor in preventing serious water erosion (Abday and Vanderwel 1997).

Soil Salinity

Soil salinity is the build-up of mineral salts on the soil surface. In Alberta, salts occur naturally in many bedrock deposits and in some deposits that lie on top of the bedrock. Groundwater flowing through these deposits dissolves and transports the salts.

Under certain conditions, this groundwater rises to the soil surface where the water evaporates and leaves the salts behind. Over time, salts accumulate in these discharge areas (saline seeps) and in high enough concentrations can prevent plant roots from taking up water and essential nutrients (Figure 3.6). This restricts plant growth and reduces crop yields.

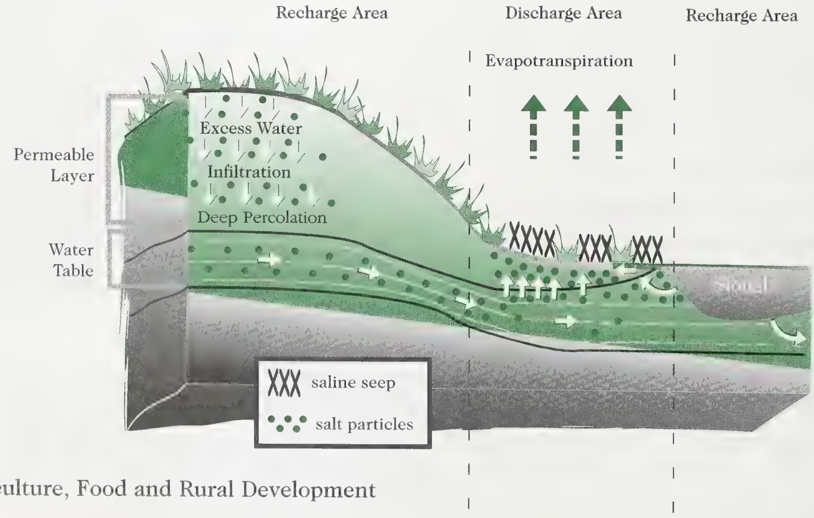
Quantifying wind erosion losses in Alberta

Recent wind erosion measurements near Lethbridge (clay loam, 15 kilometres southeast of Lethbridge), demonstrated that storm losses varied from 0.3 to 29 tonnes/ha. The total loss of exposed soils, 152.2 tonnes/ha, during the summer period points to the fragility of the soil surface after six years of continuous ***tillage***. The loss is roughly equivalent to 15.2 mm of topsoil depth.

Source: Larney *et al.* 1997.

Figure 3.6

Soil Salinization



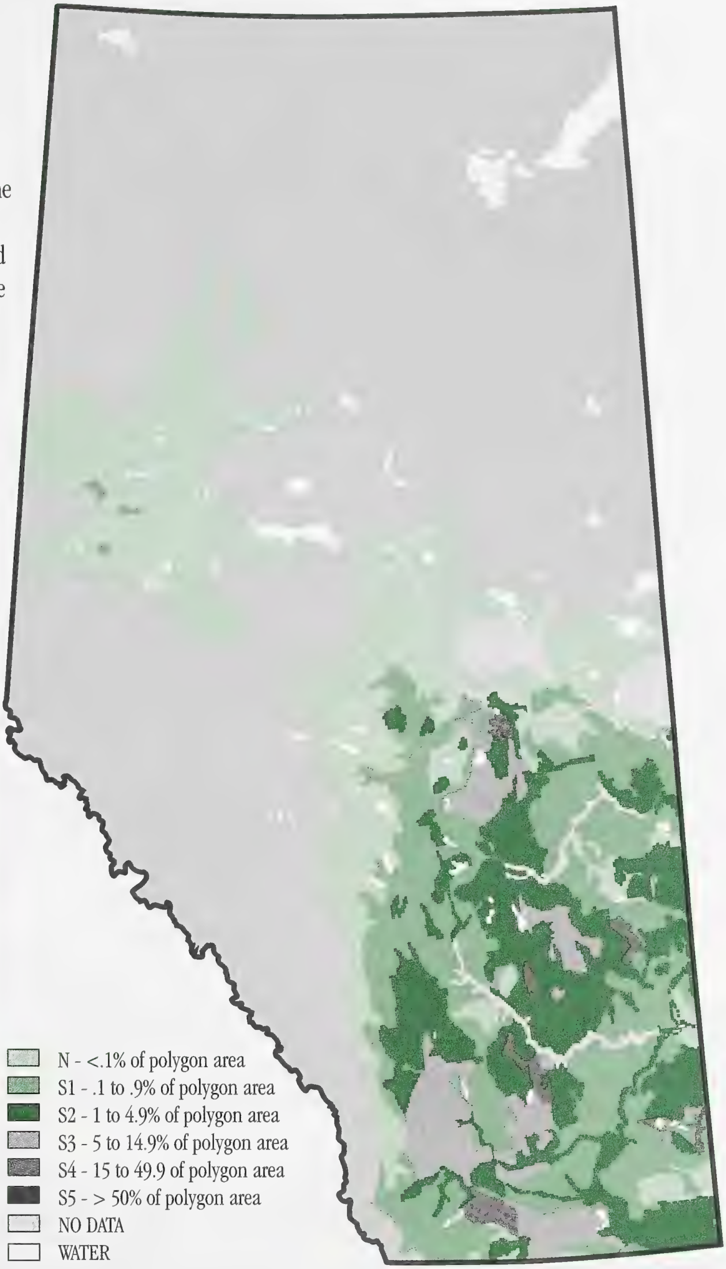
Source: Alberta Agriculture, Food and Rural Development

Figure 3.7

Presence and Extent of Soil Salinity

Dryland salinity is considered to be a significant soil degradation problem on the Canadian Prairies. In Alberta, approximately 650 000 hectares of dryland are affected by salinity, causing an average crop yield reduction of 25 percent in affected areas (Vanderpluym and Harron 1992). The extent and severity of the dryland salinity problem is increasing in some areas, and is particularly evident after a series of wet years.

Salinization of irrigated lands, especially in areas of solonetzic and saline soils, can also be a problem. The risk of salinization should be considered when planning irrigation programs.



Salinity mapping in Alberta

A program is underway to map and identify saline seeps in selected municipalities. The maps provide an inventory of the salinity problem and are an excellent tool for local agents to recommend suitable farm management practices for saline soils. To date, maps have been completed for the counties of Vulcan, Wheatland, Forty Mile, Lethbridge, Warner, Flagstaff, Newell, Beaver, and Camrose, and the municipal districts of Cypress, Willow Creek, Taber, Provost, Cardston, Starland, Rocky View and Blood Indian Reserve. These data could also be used to assess the impact of natural and farm management factors on the extent of salinity.

Pesticide Use

Pesticides are chemicals used to prevent or control weeds, insects, diseases and vertebrate pests. They include herbicides, insecticides, fungicides and vertebrate poisons. These products are rigorously tested and there are strict guidelines for their application to ensure safety, performance and value. Pesticides have helped Alberta farmers produce an abundant supply of high quality, reasonably priced food products. However, from a wildlife perspective, pesticides may also eliminate non-target species, reducing biodiversity. Special effort is required to maintain the local diversity of native flora and fauna in intensively cultivated areas.

There are many different types of invasive plant species, often referred to as "weeds", that cause problems for agriculture producers in Alberta. Some of the more important problem species include Canada thistle, chickweed, cleavers, flixweed, scentless chamomile, stinkweed, toadflax, narrow-leaved hawk's beard and wild oats. These weeds can be highly competitive, particularly if they become established before the crop. Well established weeds compete with the crop for soil moisture and nutrients. The more severe infestations can reduce yields drastically, and can constitute a significant economic loss to the farmer. For example, a light infestation of only six Canada thistle plants/square metre reduce wheat yields by 18 percent, whereas a more typical infestation of 24 plants/square metre can reduce yields by 61 percent (Alberta Agriculture, Food and Rural Development 1995a).

Tillage used to be the principal means of controlling invasive plant species on cropland in Alberta. However, changing land management practices have seen a trend toward less tillage of the soil, and reductions in the amount of ***summerfallow*** acreage. With the availability of modern day herbicides, weed control in the agricultural sector has shifted dramatically toward chemicals combined with other control methods.

There are more than 100 brand name herbicides licensed for use in Alberta. A 1996 census indicated that 46 percent of Alberta farms applied herbicides to more than six million hectares (Statistics Canada 1997a). The following trends in use are apparent for the top 12 herbicides (based on sales and theoretical area treated annually):

Significant Increase in Use:
thifensulfuron-methyl, glyphosate, fenoxaprop-p-ethyl

Relatively Steady Use:
carbathin, MCPA, 2,4-D, dicamba, bromoxynil, metsulfuron-methyl, trifluralin

Significant Decrease in Use:
triallate, chlorsulfuron

These 12 chemicals accounted for almost 83 percent of the area treated annually between 1988 and 1993 (Cotton and Byrtus 1995).

The financial cost of herbicides is highly variable. Under higher application rates, costs typically range from $12/ha to $70/ha (1997 prices). This represents a significant expense to the producer, particularly if a field requires more than one application per season to control different types of weeds. Applications may be required in the spring before seeding, and also before and after harvest.

In recent years, the number of herbicide-resistant weeds and the area they infest in western Canada has increased at an alarming rate. Much of Alberta's crop area is in the early stages of one type of resistance or another (Alberta Agriculture, Food and Rural Development, no date). Weed resistance to a particular herbicide arises through natural selection following repeated use of the herbicide for a number of years on the same field. The best methods to delay establishment of resistant weeds include regularly changing crops and herbicides, and using plant competition, mechanical methods, and other means to augment chemical control.

Insecticides are used to control insect pests such as weevils, bertha army worm, cutworm, diamond back moth larvae, and grasshoppers. These insects have natural regulators, such as weather, parasites, predators and disease. But when these regulators fail to control populations, the economic impact of insect pests can be significant. Chemical insecticides can give the needed additional population control.

Insect infestations do not occur every year and they are often limited in the areas affected. As a result, Alberta farmers use much less insecticide than herbicide. A 1996 census indicated that only 3.7 percent of farms applied insecticides to 300 000 hectares (Statistics Canada 1997a).

Two important insect pests that are responsible for widespread damage and economic loss are the bertha army worm and the grasshopper. Infestations of bertha army worms may be localized or spread over hundreds of thousands of hectares of canola, and their populations fluctuate widely from year to year. Grasshoppers are mainly grass eaters, so their damage is confined primarily to cereal crops, especially wheat and barley. Grasshopper infestations usually peak in drought years.

Using chemicals to control insect pests can have ecological consequences. Many insecticides favoured by Alberta farmers are highly toxic to other animals (for example, smaller mammals, birds, aquatic invertebrates, and fish) and to bees and other beneficial insects. Careless aerial and ground applications can cause insecticides to enter lakes with important fisheries, and the many smaller wetlands that are part of the agricultural landscape. This can affect insect life in

Insecticides used in Alberta

Based on provincial sales data, Alberta's most popular insecticide by far is lindane, an organochlorine compound. Lindane has been used to control ticks and flies in cattle, and in recent years has seen increased use to control wireworm in cereal crops and flea beetles in canola. Between 1988 and 1993, lindane accounted for 97 percent of the 800 000 hectares treated annually with insecticide (Cotton and Byrtus 1995). Deltamethrin, malathion, chlorpyrifos and carbofuran among some of the other insecticides used by farmers.

Both malathion and carbofuran are highly toxic to a wide variety of vertebrate and insect life. Carbofuran, which is particularly effective against grasshoppers, was ranked #1 for toxicity and environmental significance in a recent assessment of pesticides used in Alberta (Cotton 1995).

these water bodies. This insect life is a critical link in the food chain. Adult and larval insects are an important source of protein and energy to a vast number of vertebrate species. These include aquatic animals such as fish and waterfowl, and terrestrial forms such as amphibians, reptiles and numerous birds.

Consistent with its popularity, lindane is the insecticide most often detected at river water sampling stations in Alberta. Between 1971 and 1993, regular sampling of water quality in Alberta rivers has detected a gradual increase in average lindane (Anderson 1995). Trends towards increasing concentrations have been found in detailed studies of the North Saskatchewan River. Agricultural use in Alberta undoubtedly contributes to the presence of lindane in surface waters, but it is likely not the only source. Lindane apparently does not ***bioaccumulate*** in the environment to the same extent as other organochlorine pesticides (Donald *et al.* 1993).

Fungicides are commonly used to control leaf, root and seedling diseases. The treatment of cereal and canola seed with fungicides, and fungicide-insecticide combinations, has increased considerably in recent years. Approximately 95 percent of canola, 45 percent of barley, 37 percent of wheat, and 15 percent of oats are treated annually with fungicides in Alberta (Dorrance 1994).

Chemical Fertilizers

Fertilizer use is widespread in Alberta. The main purpose is to provide nutrients, such as nitrogen and phosphorus, to meet crop requirements. In addition, potassium and sulphur deficiencies can occur in particular areas and soil types. Deficiencies of micronutrients, such as copper, manganese, boron and zinc are less common in Alberta, but do occur.

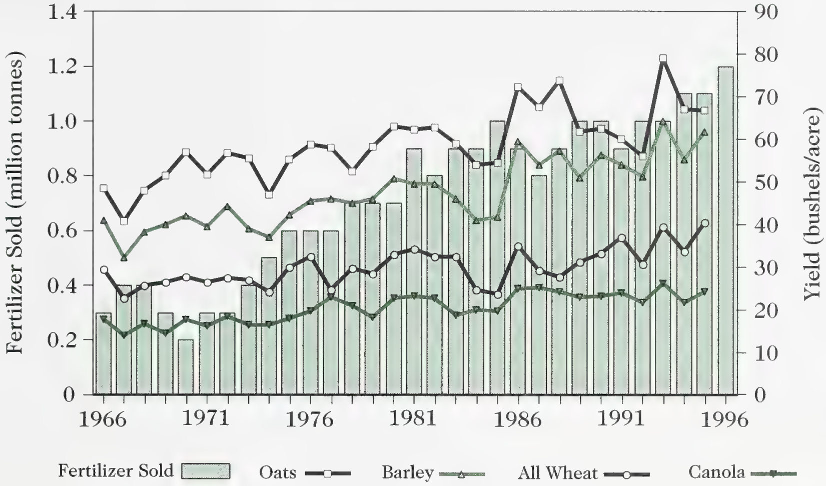
In 1996, commercial fertilizers were applied to 7.0 million hectares - 64 percent of the cultivated area (Statistics Canada 1997a). Total fertilizer sales have increased almost every year since 1966 (Figure 3.8). In that year, the volume of fertilizer used was 286 775 tonnes and in 1996 the volume was 1 150 119 tonnes - an increase of 300 percent (Korol and Rattray 1997). This dramatic increase in fertilizer use has contributed to improved crop yields and higher overall production across the province (Figure 3.8). Higher crop production was not the result of an increased land base - the cultivated area of the province increased by only 11.4 percent between 1966 and 1996. The higher production was due largely to increased yields from higher fertilizer application rates and better weed control.

Fertilizer application rates rose significantly from an average of 40 tonnes/100 ha of the total provincial crop area in 1966, to 120 tonnes/100 ha in 1996. An analysis and summary of the Alberta Farm Fertilizer Protection Plan database has concluded that the majority of fertilizer application rates continue to be within the expected and recommended levels (Kryzanowski 1995).

Fertilizers applied to agricultural lands also have the potential to enter lakes and rivers. Excessive nutrient loading in waterbodies can cause ***eutrophication***. It can also create suitable conditions for poison-producing organisms, such as blue-green algae and the avian-botulism bacterium.

Figure 3.8

Total Fertilizer Sold and Yields of Major Crops in Alberta, 1966 to 1996



Source: Agriculture and Agri-Food Canada (1997) and
Alberta Agriculture, Food and Rural Development (1995b)

Land Productivity Index

Alberta Agriculture, Food and Rural Development uses the Alberta land productivity index to measure progress in land stewardship. Wise land management is essential to produce good yields of healthy crops to feed Albertans and the world.

The index is calculated yearly based on the yields of the major cereals, oilseed and forage crops in tonnes. To allow for differences in the relative weights of different crops, production per acre for each crop is converted to a standard base – tonnes per acre of wheat equivalent yield. This allows for productivity comparisons without the need to worry about differentiating between crop choices.

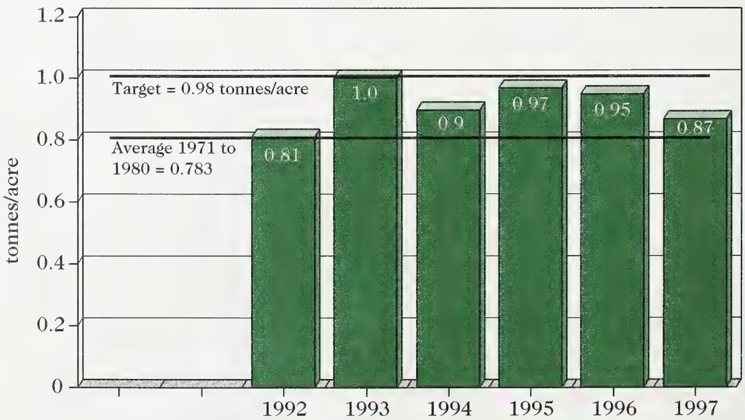
The index shows that crop yield has grown steadily over the last 45 years, with improved land management practices. Crops use nutrients from the soil in order to grow and produce seeds. Farmers use manure and chemical fertilizers to replace the nutrients to meet the needs of the next crop. Also, farmers use a variety of practices, like reducing the amount of tillage, to conserve soil nutrients. The increase in crop yields shows that farmers are successfully improving yields while maintaining nutrient levels. Good nutrient levels are a key component in maintaining and improving land productivity.

The data used to calculate the index show that the total harvested acres have also increased over the last 45 years. In recent years, the increased area has been primarily due to a decrease in the amount of summerfallow. Summerfallow – when the land is left unplanted during the growing season – is used by some farmers to store soil moisture in dry areas or to control specific weed problems. However, summerfallow land is at risk to soil degradation because the soil surface is left exposed to the elements. The decrease in summerfallow acres is a positive and important management factor in improving soil quality and land productivity.

To assess progress in land stewardship, Alberta Agriculture, Food and Rural Development considers the index in comparison to a baseline value of 0.783 tonnes per acre, based on 1971 to 1980 data. These years represent the benchmark of the adoption of modern agricultural technology. Development of other indicators of the agri-food industry's environmental sustainability is underway.

Figure 3.9

Alberta Land Productivity Index



Source: Alberta Agriculture, Food and Rural Development

Nutrients from chemical fertilizers, principally nitrogen and phosphorus, enter surface waters through runoff from snowmelt and rainfall directly, or via the sediment load it is transporting. This type of "nutrient loading" is more pronounced in watersheds where a large proportion of the landscape is under intensive agricultural use. Data from a recent study show that drainage streams in areas with high intensity farming tended to have higher nitrogen and total phosphorus concentrations than drainage streams in low intensity farmed land. In many cases of high and medium intensity area streams, nitrogen and phosphorus levels were consistently higher than the Alberta Surface Water Quality Interim Guidelines (CAESA Water Quality Committee 1996).

Most agricultural producers monitor soil nutrient levels and try to limit the application of fertilizer to the amounts needed by the growing crops. Applying any excess fertilizer represents a waste of time and money for the producer.

Manure Handling and Use

In response to increasing domestic and international market opportunities, some provincial livestock and poultry operations are growing in both size and number. Higher densities of concentrated feeding operations increase the importance of proper manure storage and handling. Although most livestock and poultry producers do a good job of managing manure, problems can occur if manure is applied to fields beyond the nutrient needs of the crops. The risk of contamination increases when excess nutrients and coliform bacteria leach into shallow groundwater or run off into surface water bodies. In 1996, manure was applied using solid and liquid spreaders to a total of 475 390 hectares (Statistics Canada 1997a).

Manure and feed wastes can also enter water bodies when manure is spread on steeps slopes or on frozen soils that drain toward surface water, or when cattle are wintered or fed along watercourses. Studies at Pine Lake in central Alberta suggest that the most important sources for nutrients entering the lake are runoff streams with larger livestock winter feeding areas within their watersheds (Sosiak and Trew 1996). Improper manure handling can also produce odors that may become a nuisance to neighbours.

Crop Land Use

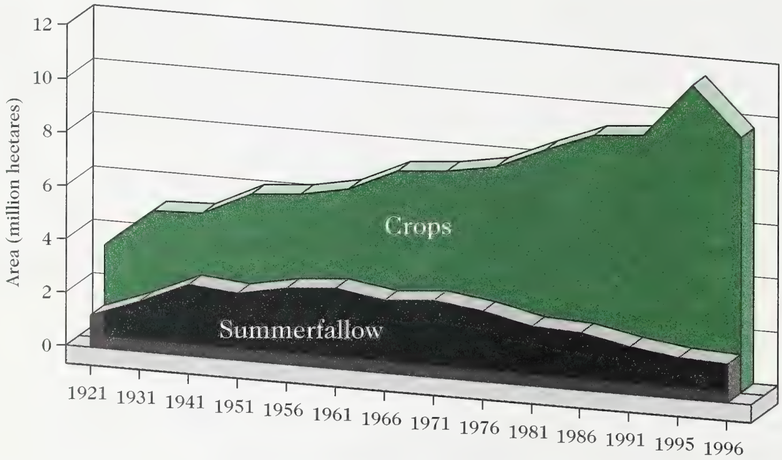
Fallowing is the practice of leaving the land without a crop during the growing season. This practice can conserve soil moisture for the next growing season and control problem weeds. However, tilling summerfallow fields to control weeds dries out the surface soil and leaves it prone to wind erosion. The bare soils are also more prone to water erosion from rainfall and snowmelt. Excessive tillage increases aeration and soil temperature, thereby increasing the rate of decomposition and causing a reduction in soil organic content. With no plants to

use soil moisture, excessive precipitation can percolate down through the soil and cause water-soluble crop nutrients and salts to enter groundwater. The results can be high nitrate levels in ***aquifers***, and increased soil salinity in groundwater discharge areas.

Technological advances in cultivation equipment have lessened the severe soil erosion problems associated with summerfallowing. The more recent large-scale use of herbicides has reduced the need to control weeds by tillage. In the years between 1941 and 1961, summerfallow fields accounted for almost one-half of the total annual field crop area. Since that time, the proportion has decreased dramatically, reaching 13 percent of the total cultivated area in 1996 (Figure 3.10) (Statistics Canada 1997a).

Figure 3.10

Total Area of Land Occupied by Crops and Summerfallow in Alberta, 1921 to 1996



Source: Statistics Canada (1997) and Alberta Agriculture, Food and Rural Development

Value of Soil Organic Matter

Crop residue (straw, roots and other plant parts left after the crop has been removed) helps to maintain the soil's organic content. Organic matter increases *tilth*, serves as a reservoir to store and release nutrients, and increases water infiltration and storage in the soil. Removal of crop residues and excessive tillage tends to decrease soil organic matter over time. Some experts have indicated that the value of crop residue as organic matter is equivalent to its nutrient value (about $13 to $15 per tonne).

Case Study: Sharp-tailed Grouse

The sharp-tailed grouse, or prairie chicken, is native to the grassland and parkland regions of Alberta. Sharp-tailed grouse populations have been declining over the years largely due to habitat loss. Over the past 30 years, it is estimated that native prairie habitats have declined by 50 to 75 percent, primarily as a result of land being converted to agricultural use.

The remaining native rangelands are critical for the reproductive success of sharp-tailed grouse. During the breeding season, the species depends on open grassland and shrubland communities for courtship and nesting. Shrubs and dense grasses provide plenty of food, as well as cover to help the birds hide from their numerous predators.

Through the Sharp-tailed Grouse Habitat Program, Alberta Environment and the Alberta Conservation Association are working closely with cattle ranchers and landholders to improve the sharp-tailed grouse's habitat and numbers. In cooperation with landowners, the program's long-term goal is to enhance habitat on more than 160 000 hectares in the prairies and the Peace River area of northwestern Alberta. The focus is the incorporation of ecologically-based range management that benefits both livestock and wildlife. Since 1995, the program has contributed to improving more than 28 000 hectares of grassland habitat, and has identified important habitat areas and found populations of sharp-tailed grouse on private and leased lands. The program is also helping increase knowledge about the grouse's nesting and brood-rearing needs, information that will help land managers measure the sharp-tailed grouse's habitat requirements.

Grazing Land Use

Between 1966 and 1996, the total cattle herd in Alberta has increased from 3.44 million animals to 5.9 million - an increase of more than 60 percent. Over the same time period, the total amount of rangeland, both native and tame pasture, has decreased from 9.72 million hectares to 8.55 million hectares. Some of this decrease is market-driven, with conversion from rangeland to cropland when the price of grains is favourable. As well, many cattle are fed grains and silage, rather than grazing them on pastures.

Rangelands in Alberta may experience even greater demands with a forecasted expansion of the beef cattle herd. A recent study by Alberta Agriculture, Food and Rural Development examined the resources necessary for beef herd expansion and concluded that rangelands are at capacity, and possess little or no unused potential for herd expansion on native range (MacAlpine *et al.* 1997).

The prevailing indicator of rangeland sustainability is range condition. Range condition is rated in four classes including excellent, good, fair and poor. Range condition in Alberta has improved substantially since the dust bowl era, prior to which most rangelands in North America were subject to excessive grazing. In general, proper range management practices will maintain good to excellent range condition, while overgrazing will lower the status of plant communities to the fair or poor categories.

Cattle compete with grazing wildlife when forage is limited. This is especially important on winter range for elk and deer, who depend on adequate forage to survive the winter. It is important to consider the needs of both wildlife and livestock when designing grazing programs.

There is growing recognition that well managed ranching operations help to maintain open spaces, and the flora and fauna found there. When drought occurs, as it did in the 1980's and early 1990's, livestock producers face the dilemma of reducing the number of cattle on the range or damaging their rangeland. By reducing stocking levels during a drought and supplementing grazing with additional forage, producers help to maintain plant vigour and vegetative cover. This, in turn, helps promote a balance between resource use and ecosystem health, maintaining habitat for native plants and animals on Alberta's rangelands.

Focus Issue - Riparian Areas

Riparian areas are lands along rivers, streams and wetlands where water strongly influences the vegetation. Riparian areas can vary in size from broad, forested floodplains in major river valleys, to small clumps of lush grasses and willow along small meandering creeks. Regardless of their size or complexity, riparian areas are very important. A healthy riparian area along a stream, for example, is covered by a diversity of plants with strong root systems. This protects the banks from erosion and slows down the flow of water, trapping sediments and resulting in more groundwater storage. A healthy riparian zone translates into better water quality for fish and other aquatic life, humans and livestock. The diversity of vegetation, healthy productive plant growth, and proximity to water also attracts greater numbers and variety of wildlife. However, what makes these areas attractive to wildlife also makes them attractive to livestock.

Because of their high moisture availability, riparian areas are important for forage production. Livestock grazing on Alberta's rangelands, including riparian areas, has a history dating back more than 100 years. Over time, poor grazing management in greener, more productive riparian areas has led to symptoms of overuse. In many cases, these symptoms include poor vegetative cover, excessive

streambank erosion, poor water quality, and reduced populations of fish and wildlife (Adams and Fitch 1995).

Since 1993, the agriculture industry has worked with the provincial government and a number of other partners to help livestock producers recognize the effects of grazing on riparian ecosystems and to apply grazing strategies that will restore a riparian area's health (see Sustainable Grazing Systems in section 3.1.3). Fencing to exclude cattle, grazing rotation, and the use of alternative water sources have shown positive results (Adams and Fitch 1995).

3.1.3 Actions

Canada-Alberta Soil Conservation Initiative

The Canada-Alberta Soil Conservation Initiative (CASCI) was a $34.2 million initiative of the governments of Alberta and Canada. CASCI was part of a long-term strategy developed by the governments to conserve soil resources in Alberta. Its goal was "to encourage practices which conserve Alberta's soil resource and sustain its long-term productivity, within practical economic limits and according to the soils capability". To achieve this goal, CASCI supported a broad range of programs and projects from 1989 to 1992. Agricultural service boards, producer and non-producer groups and other agencies such as Prairie Farm Rehabilitation Administration (PFRA); Alberta Agriculture; Ducks Unlimited; and various researchers undertook a number of programs and projects to increase soil conservation. These included education, ***technology transfer***, planning, land use change, research and monitoring.

Canada-Alberta Environmentally Sustainable Agriculture Agreement

The Canada-Alberta Environmentally Sustainable Agriculture (CAESA) Agreement was a five-year, $34.3 million agreement between the governments of Alberta and Canada from 1992 to 1997. The purpose of CAESA was to address issues related to the environmental impacts of agriculture. Priority issues included soil resources, water quality, water quantity, pollution and waste management, wildlife habitat, genetic resources, air, climate, and energy. Projects were delivered through producer groups, municipalities, native agricultural groups, applied research agencies, government agencies and universities. CAESA supported technology transfer and research on production and processing practices.

Alberta Environmentally Sustainable Agriculture Program

Alberta has continued CAESA's momentum through a new initiative - the Alberta Environmentally Sustainable Agriculture (AESA) Program. AESA helps with the development of new information and research on environmentally sustainable agriculture; transfers new technology and information into the hands of farmers, ranchers, and processors; and monitors the impact of the agriculture industry on soil and water quality. Funding for the program is approximately $5 million annually. This commitment represents a doubling of provincial investment in programs for environmentally sustainable agriculture to replace the withdrawal of federal funding. Funding supports four main components: farm-based, research, processing and monitoring (soil and water). The AESA Program priorities were established through stakeholder consultations and are directed by the AESA Council. The Council is appointed by the Minister of Agriculture, Food and Rural Development and has a broad-based industry membership.

Sustainable Grazing Systems

Sustainable grazing management systems allow grazing land to rest and recuperate from the cropping and trampling of grazing activity. These systems may include alternative pasture watering systems to protect riparian areas, riparian area management plans, deferred grazing, rest rotation and time-controlled systems. This protects the land's soil and water quality and conserves its wildlife habitat.

The Alberta Riparian Habitat Management Program, also know as the "Cows and Fish" project, was established in 1992 through a partnership agreement between the Alberta Cattle Commission; Trout Unlimited Canada; Canadian Cattlemen's Association; Alberta Environment; Alberta Agriculture, Food and Rural Development; and Fisheries and Oceans Canada. The program partners are working together to foster a better understanding of how improvements in grazing management can improve the health and productivity of riparian areas. These improvements can benefit ranchers, fish, wildlife and others who use and value riparian areas. Important to the success of the partnership has been the cooperation of 11 southern Alberta ranches that have applied grazing strategies to restore riparian area's health, or shared existing grazing practices that have maintained riparian health. The program has expanded beyond southern Alberta, and it is now province-wide.

For more information on this topic, see "Caring for the Green Zone", a guidebook that was developed to provide information and examples for riparian area and grazing management (Adams and Fitch 1995).

Permanent Cover Program

The Permanent Cover Program was a Canadian conservation initiative delivered for Agriculture and Agri-Food Canada by the Prairie Farm Rehabilitation Administration (PFRA). Involving the provinces of Manitoba, Saskatchewan, Alberta and British Columbia, the program was offered twice - in 1989/1990 and 1991/1992. The program encouraged landowners conserve soil, and to grow perennial vegetation where cultivation was degrading the soil. Landowners were given a one-time financial incentive to convert eligible, high risk lands to permanent vegetation cover or perennial forages. In exchange, the landowner agreed to keep the land in permanent cover for a 10 or 21 year period. Producers were permitted to use forage produced on this Permanent Cover Program land.

In Alberta, just over $29 million was committed to converting 213 200 hectares to permanent cover. The program promoted soil conservation while complementing the efforts of wildlife agencies such as Ducks Unlimited Canada and Alberta Environment's Buck for Wildlife Program.

Although the program no longer provides funding, its benefits are still being felt and will be beyond the year 2000. They range from reduced soil erosion and an improved, more valuable soil resource, to sustainable forage production or livestock grazing, restored wildlife habitat, reclaimed saline soils (one method) and an improved appearance of the landscape and natural environment.

Responsible Pest Management

Responsible pest management involves the cost-effective and environmentally safe use of pesticides, integrated pest management systems and biological control methods. Most producers use an integrated approach of some form to manage pests.

Alberta promotes cost-effective and environmentally safe use of pesticides in many ways, including the following:

1. Commercial applicators of pesticides are licensed and trained by Alberta Environment.
2. The Farmer Pesticide Certificate course, established by Alberta Agriculture, Food and Rural Development in association with Olds College in 1990. The course teaches farmers how to avoid unnecessarily exposing themselves and the environment to pesticides. More than 3400 farmers have voluntarily enrolled in the course since it began.
3. Crop Protection by Chemicals (the "Blue Book"), an annual publication available to Albertans, lists which pesticide is best to control a target pest, and the pesticide's recommended application rate, proper handling techniques, and emergency information.
4. Many other publications that provide information about pesticide use and general pest control methods. This written information is complemented by 1-800 hotlines (to private industry), and consultations both with Alberta Agriculture, Food and Rural Development crop specialists, and private agriculture consultants.

Integrated Pest Management is a system of managing pests that a combination of different control methods - cultural, biological or chemical - in a program that is both economically and environmentally sound. The objective is to keep pest species below the population threshold that causes economic loss. Integrated Pest Management involves pest identification, monitoring pest and beneficial species, determining pest thresholds and then choosing the best combination of control options. Disease resistant varieties, crop rotation, pesticide rotation, clean equipment, competitive crop types, high seeding rates, and good fertilizer placement are also an important part of the system.

Genetically engineered crop varieties that can survive specific, broad-spectrum herbicides are now available. The seed is expensive and highly regulated but it reduces weed control costs and lowers pesticide levels in the environment.

Biological control of weeds by using insects or disease is an environmentally sustainable alternative to chemical control. This is especially true in rangeland, pasture and other uncultivated land. Bio-control targets a weed with its specific natural enemies found in its native range, but not native to Canada. Many years of research, testing, quarantine, and production are needed before insects or diseases are released in Alberta. This is done in cooperation with Agriculture and Agri-Food Canada; international agencies; Alberta Agriculture, Food and Rural Development; the Alberta Research Council; and agricultural fieldmen. In 1996, there were encouraging signs that several bio-control agents were successfully introduced against Canada thistle, field bindweed and common toadflax. The control of leafy spurge with biological agents is also an established practice in some areas. New agents have also been screened or identified for scentless chamomile, common tansy and false cleavers.

Control of Leafy Spurge

Cattle do not eat leafy spurge and will avoid grazing areas where it is present. Leafy spurge also competes with pasture and rangeland grasses, which further reduces the capacity of infested land to feed liverstock. Leafy spurge is difficult and costly to control for extended periods with herbicides.

Leafy spurge was introduced from Eastern Europe, where natural insect predators and disease keep it from becoming a serious weed problem. For Canada's leafy spurge bio-control program, several insects were extensively screened to ensure that they would feed only on leafy spurge and not harm native or cultivated plants in Canada. The black dot spurge beetle was selected and introduced to Alberta from Hungary in 1983.

On suitable sites, the spurge beetles can reduce a leafy spurge population to less than three percent cover within three years. Spurge beetles are a good alternative for controlling leafy surge in pastures, rangeland and other suitable non-crop land areas. Once established on a leafy spurge infestation, spurge beetles provide continuing control without additional expense.

(Alberta Agriculture, Food and Rural Development 1991)

Genetically engineered crops are also being developed as a bio-control for insects. Some genetically engineered crops use a naturally occurring insecticide produced by the soil bacterium *Bacillus thuringiensis*, commonly known as Bt. Bt genes are used in potatoes to control potato beetles and in corn to control corn borers. Bt genes are also being bred into canola to develop canola strains resistant to flea beetle and maggots. These methods can control pests without the environmental impact of insecticides.

Crop Management Systems

Excessive tilling can result in soil quality deterioration, soil loss through erosion, and changes to local water quality. New programs are now gathering data to help tackle the effect of crop production on the organic content and overall quality of the soil. In addition, several land management practices are revolutionizing Alberta farming. Reduced tillage, zero-till, and site-specific management systems reduce the environmental impact of crop production. Specific farm management practices that can reduce soil erosion include:

- Minimum tillage - reducing the number of tillage passes to maintain at least 30 percent ground cover.
- Zero-till seeding (direct seeding) - seed and fertilizer placement into previous untilled stubble.
- Cover cropping - crops are grown in rotation, but used for ground cover (mostly during the winter) rather than harvest.
- Strip cropping - planting different types of crops in narrow alternate strips to prevent erosion. Strips are usually planted across the slope or across the direction of the prevailing wind.
- Chemical fallow - leaving the land unplanted for one growing season. Herbicides rather than tillage are used to control weeds.
- Crop residue management - maintaining at least 30 percent ground cover by spreading straw evenly across the land.
- Fall-seeded crops - planting fall rye and winter wheat contributes to soil and water conservation and benefits local wildlife.

Technological advances in crop production (chemical, equipment and management practices) have also lessened the severe soil erosion problems associated with summerfallowing. In particular, herbicides are sometimes used to replace one or more tillage operations to control weeds. Reduced soil erosion means more topsoil, the potential for healthier soil, and consequently, better crops.

As an alternative to tillage, crop areas at high risk from water erosion due to steep slopes or erodible soils may be better suited to forage production or grazing. Wooded areas with poor soils and steep slopes can be left in their natural state and managed as woodlots. In hilly, tilled areas, cultivating and planting across the slope, rather than up and down, slows down the flow of water and increases its absorption into the soil. Other ways to control water erosion include maintaining organic material and crop residue cover, minimum tillage, zero-till, and chemical fallow. To control severe water erosion, grassed waterways, lined channels, drop structures, contour farming and gully control are necessary.

In some locations, another consequence of excessive tillage is soil salinity. Farm management practices to control salinity include reducing summerfallowing, planting forage, planting alfalfa in groundwater recharge areas and salt tolerant grasses in saline areas, and installing relief wells connected to suitable outlets. The specific salinity control method depends on the type of salinity.

Zero tillage

In Alberta, the area of zero-till increased 215 percent between 1991 and 1996 to 784 000 hectares. This area represents ten percent of all land prepared for seeding. Since, 1991, the area tilled where the soil surface retained most of the crop residue has increased 29 percent to 2.5 million hectares. This represents 33 percent of the total land prepared for seeding in 1996 (Statistics Canada 1997a).

Alberta Agriculture, Food and Rural Development has specialists throughout Alberta who provide advice and information to farm managers about crop management systems and soil conservation practices.

Alberta Reduced Tillage Initiative

The Alberta Reduced Tillage Initiative is a broad-based partnership that provides practical information on reduced tillage to farmers through meetings, workshops and demonstrations. The main goal is to reduce the amount and intensity of tillage in Alberta. Partners include the private sector, producer and wildlife conservation groups, educational institutions, government (federal and provincial), and environmental funding agencies. The initiative was established in 1994. In 1997, the partners renewed and expanded the initiative for an additional three years.

Field Shelterbelt Program

Field shelterbelts are an important conservation management tool on many farms in Alberta. These bands of trees and shrubs are effective barriers to the wind, providing protection to the adjacent soil and crops. Shelterbelts can trap snow and increase the available moisture content of the nearby soil, improving adjacent crop yields (Sprout *et al.* 1997). Other benefits include improved aesthetics and, if managed appropriately, wildlife habitat. Initiated under CASCI, the Alberta Field Shelterbelt Program and the PFRA made trees and shrubs available to farmers and non-profit groups free of charge for shelterbelt plantings. In addition, most municipalities have a shelterbelt program to complement tree orders from Alberta nurseries. Between 1989 and 1996, 4.5 million field shelterbelt trees were planted. This is equivalent to about 4500 kilometres of single-row shelterbelts.

Shelterbelts and wooded areas have many environmental benefits ranging from soil conservation and water quality protection to biodiversity and wildlife habitat enhancement. Proper planning and sustainable management of these areas can improve environmental stewardship. As their awareness of sustainable management increases, landowners are becoming more selective in the management choices they make. Overall, shelterbelt and woodlot education is proving an effective way of minimizing the potential for environmental damage.

Network of Benchmark Sites

Agriculture and Agri-Food Canada, in cooperation with provincial agencies, has established a national network of benchmark sites to monitor long-term change in soil quality and develop environmental degradation indicators. Four Alberta sites are being maintained and monitored as part of the Soil Quality Program, initially under CAESA and now under AESA. The sites are located in brown

(irrigated), dark brown, black and dark gray soils. Baseline work consists of detailed sampling and repeated field measurements of many variables over three years. Annual observations include weather, soil and crop measurements.

Equipment Development

Industry has developed seeding and residue management equipment to suit the needs of conservation farming. Through research, development and evaluation of machinery and related technologies, significant advances have been made toward solving production problems, increasing field efficiencies and adopting conservation practices. The Alberta Farm Machinery Research Centre has completed many development projects for industry over the years including sprayer rate controller tests, air seed application development (for minimum and no-tillage), spray formulation field and lab tests, drift control device development and pump tests. Centre staff also designed and built a no-till grass seeder in cooperation with the County of Forty Mile.

Soil Conservation Act

The *Soil Conservation Act* (1988) ensures that every landowner takes appropriate measures to prevent soil loss or deterioration. If soil loss or deterioration is occurring, the landowner is required to stop it from continuing. The Act allows both the local municipality and the province to appoint soil conservation officers and direct a landowner to take necessary measures to prevent or stop soil loss. If the landowner does not comply, the work may be completed by the government at the landowner's expense.

Usually the people promoting soil conservation for the municipality are the soil conservation officers. Officers alert landowners of problems, which helps landowners to take action to prevent soil loss or deterioration.

Code of Practice for Livestock Producers

Through the cooperative efforts of the livestock industry, municipal governments, and various interested provincial departments, the third edition of the Code of Practice for the Safe and Economic Handling of Animal Manures (1995) was developed. The code guides the establishment and operation of livestock facilities by providing standards of conduct for the industry that are in keeping with current environmental, economic, and social expectations. This helps producers minimize the potential for nuisance and environmental problems. It also is used by some municipalities to evaluate development permit applications for intensive livestock operations, and as a framework of agricultural standards for the enforcement of provincial legislation.

The code also promotes livestock manure as a valuable resource for improving soil fertility and conservation, and for useful by-products. The code emphasizes

the use of land as a recycling system where manure nutrients applied to farmland balance those removed by the crops grown.

A new and updated provincial regulatory approach to intensive livestock operations is under development.

Conservation Easements in Alberta

In September, 1996 the *Environmental Protection and Enhancement Act* was amended to allow private landowners to enter into conservation easement agreements with qualified conservation groups, a local authority, and the provincial government. A conservation easement is a voluntary agreement between a landowner and a second party interested in protecting the natural value of the land. The agreement is registered on the land title and places conditions on the land's use that serve conservation purposes.

Conservation easements are mainly used for conserving natural areas or wildlife habitat on private land. Easements offer several personal as well as practical benefits. These include the knowledge that the land's natural values will be protected and a potential income tax credit. Easements also help conserve biodiversity by protecting natural habitat.

3.1.4 Future Directions

Sustainable Growth in Agricultural Production and Processing

World population, per capita income and the demand for food are on the rise. Alberta's geographical location allows good access to a host of consumers: eight million in western Canada, 50 million in the western United States and millions in the Pacific Rim market. The North American Free Trade Agreement and negotiations in the Pacific Rim are helping provide further access to these markets.

Alberta's vision for the agriculture industry over the next ten years includes a doubling of the primary sector to a $10 billion industry and a quadrupling of the processing sector to a $20 billion industry. Expansion and intensification of agriculture in Alberta may place additional pressures on the terrestrial ecosystem. Industry and environmental organizations in Alberta agree there is a need to ensure this expansion takes place in an environmentally sustainable manner based on the best science and information available.

Limited Irrigation Expansion

The development of irrigation in Alberta has been progressing for over 100 years. Additional large-scale expansion is limited by the amount of water available.

The *Water Act* sets out the regulatory framework that controls how water in Alberta is allocated, stored, and diverted. The South Saskatchewan Basin Water Allocation Regulation has established a limit of 688 260 hectares of irrigation development in the South Saskatchewan River Basin. Irrigation development in the basin is nearing this limit.

There are two new water management projects underway within the South Saskatchewan River Basin. The Pine Coulee Dam is under construction and will provide the potential to expand the 5260 hectares currently irrigated to 8500 hectares. The Highwood-Little Bow Diversion project is being reviewed by the Natural Resources Conservation Board. If approved, it will provide the potential to expand the 6475 hectares currently being irrigated to 14 570 hectares.

Precision Farming

Precision farming, sometimes called site-specific farming, is a new technology that allows farmers to adjust their operations to take advantage of the variations in their fields in characteristics like soil fertility and weed populations. Precision farming relies on the global positioning system (GPS), which uses satellite signals to precisely locate the user.

With this information and on-board sensors, advanced farm equipment can monitor crop yields and guide the more efficient and effective application of fertilizers and herbicides. This helps reduce farming's environmental impact by allowing farmers to apply chemicals only where they are needed at an appropriate rate. Research is underway to further improve the technology, and courses are available through community colleges to learn its practical applications.

Emerging Markets

Functional Foods

Functional foods (other terms include designer foods, pharmafoods, vitafoods, super foods, nutraceuticals, probiotics) all refer to foods or food components that provide a physiological benefit in the prevention and/or treatment of disease, and promote optimal health beyond traditional nutritional value. Examples of functional foods in Canada include isotonic beverages for athletes, eggs with enhanced omega-3 fatty acids, fat substitutes based on modified starches, and fruit flavoured carbonated bottled water with calcium to prevent osteoporosis.

Interest in functional foods is growing, thanks to a variety of market factors: increasing clinical data, an aging population, consumer nutrition awareness, media attention, advances in food technology, new products, international market opportunities and government policies for containing health care costs. The potential market for functional foods is growing worldwide.

Alternative Straw Use Industry

Several new industrial uses for straw are being explored and promoted. Straw as a replacement for wood fibre in paper and panel board products is receiving considerable attention.

It is estimated that a million tonnes of wheat straw are available for alternative uses during an average year in Alberta. This is after soil conservation and livestock uses are satisfied. The excess straw occurs mainly in the black soil zone. In other areas, sufficient straw to satisfy both the livestock and conservation demands is lacking. There are still some technological challenges to overcome but several businesses are pursuing the potential of this industry in Alberta. (Alberta Agriculture, Food and Rural Development and Prairie Farm Rehabilitation Administration 1996).

A strawboard plant is proposed for the Thorhild area and production is expected to be in full swing by early 1999. The plant will produce Goldboard, a composite panel board that matches the strength of premium-quality wood particleboard, but weighs less. Another Goldboard plant is proposed for central Alberta, to be operated by the Golden Stem Co-op. Currently, there is a strawpaper plant operating in Vulcan, under the name Canadian Flax Pulp Plant.

Alternative Fuels

Alberta is rich with energy resources in the form of fossil fuels (oil, gas and coal). Unfortunately, when fossil fuels burn they release emissions containing greenhouse gases. Greenhouse gases, measured in carbon dioxide equivalents, build up in the atmosphere and can affect climate and weather patterns. Global climate change, sometimes called global warming, is considered to be a widespread effect of greenhouse gases.

One method to reduce greenhouse gas emissions is to find cleaner burning fuels. Coupled with this burden is also the realization that Alberta can and will run out of fossil fuels, a non-renewable resource, at some point in the future. Alternative fuels produced from renewable resources such as cereal grains, oilseeds and forages can be more sustainable and burn cleaner than fossil fuels.

Ethanol is an example of a clean burning fuel that can be produced from the fermentation of cereal grains (wheat and barley). Compared with other alternative fuels, ethanol performs well but has high production costs (Olsen 1992). As a result, ethanol will most likely be used as a fuel additive to improve the performance characteristics of gasoline. Gasoline containing ethanol burns cleaner and releases less harmful exhaust gas emissions. A by-product of ethanol production from grain is a high-protein livestock feed ingredient. At present, there are plans to locate ethanol plants in the County of Strathcona, and near Killam, Red Deer and Two Hills.

Biodiesel is another alternative fuel. Burning biodiesel in diesel motors sharply reduces emissions, including particulates, from that of petroleum diesel. Biodiesel is made from renewable resources, such as soybean, canola or other oilseed and vegetable oil sources, through a simple refining process.

The current key biodiesel markets are mass transit, marine and other environmentally sensitive areas, such as mines. Biodiesel's potential in these markets is still under investigation. However, over 100 cities around the world have run demonstrations or test projects using biodiesel, involving more than 1,000 buses and several million kilometres of travel. France is currently the world's largest producer of biodiesel, using it as heating oil and also in 50 per cent blends with petroleum diesel. Biodiesel is undergoing extensive testing in Canada and the United States. Currently, there are no biodiesel production plants planned for Alberta.

Other

There are other potential non-food uses for agricultural products in Alberta. Native starches from corn, wheat, potato or rice can be treated to produce various by-products. The sucrose derived from sugar beet sugar is used in detergents and polymers. Dairy by-products, such as lactic acid, are used as preservatives in food products, raw materials for emulsifiers, and as flavour enhancers. There is also the potential to process vegetable oil crops for the industrial ***lipid*** market. And plant based ingredients, such as wheat germ oils and proteins, can be used in personal care products. With our current technology and agricultural resources, the final product possibilities seem endless.

3.2 Forested Lands

Alberta's forested lands cover large portions of the province, from the vast boreal forest in the north to the ribbons of riparian cottonwood found in many river valleys of the southern grasslands. Timber for wood and fibre products is one of a range of benefits that forests supply. Many non-renewable resources, including conventional oil, oil sands, natural gas, coal, peat, sand and gravel, are also obtained from forested land. Although these industries do not rely on trees, they can significantly affect forest landscapes and forest management.
(See section 3.3.)

Alberta's forests are also important for other reasons. Forests provide natural habitats for plants and animals. Many wildlife species support the hunting, trapping, guiding and outfitting industries. Several important fur-bearing species, such as wolf, lynx, fisher, marten, mink, snowshoe hare and red squirrel, are primarily forest species. Forests are also important as a setting for recreation, including camping, hiking, cross-country skiing, and nature interpretation. All of Alberta's national parks and most of our provincial parks and recreation areas are located in forest ecosystems.

Perhaps most important of all, Alberta's forests play a vital ecological role. Forests are key in the cycling of the Earth's carbon, oxygen, nitrogen and water. Like all green plants, trees use the sun's energy for photosynthesis — a process that absorbs carbon dioxide from the atmosphere while emitting oxygen. Therefore, Alberta's forests actively store carbon, which may reduce the speed of global climate change, sometimes called global warming. They also help purify the air, protect watersheds, and control erosion.

3.2.1 Present Conditions

Forest Resources

Forested lands in Alberta occupy about 60 percent of the total provincial area. Approximately 351 000 square kilometres of the total forested area is located within the Green Area. Of this, approximately 64 percent (225 000 square kilometres) is timber-productive forest. In Alberta, timber-productive forests are defined as those areas capable of yielding 50 cubic metres/hectare of wood volume within 120 years (Alberta Environmental Protection 1994). The remainder of the Green Area is reserved lands (for example, parks, protected areas, federal lands), lakes and rivers, or less productive forests such as those in bogs and muskegs.

Alberta's forests feature a variety of tree species. White spruce, black spruce, lodgepole pine, jack pine, balsam fir, Douglas fir and tamarack are the most common coniferous species. Aspen, balsam poplar and white birch are the most common deciduous species. In the timber-productive area, almost 50 percent is pure coniferous stands, about 30 percent is pure deciduous, and the remaining 20 percent is a mixture of coniferous and deciduous trees (Alberta Environmental Protection 1994).

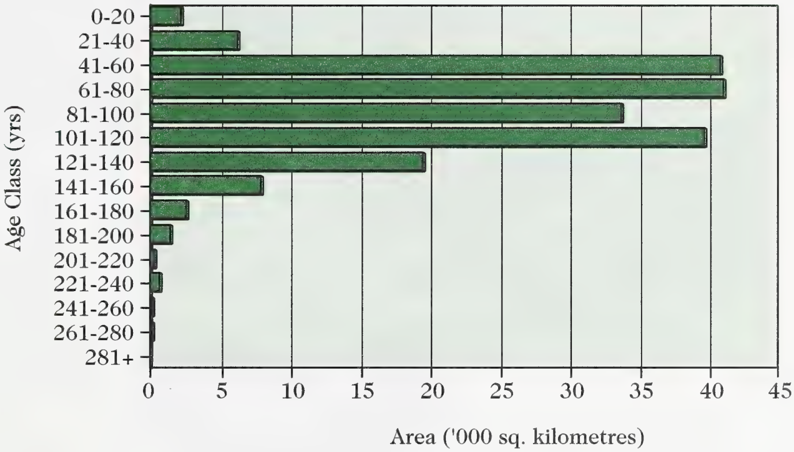
Forest inventory records show that the forests in Alberta are relatively young. Due to a history of frequent forest fires, approximately 70 percent are less than 120 years of age. The majority (55 percent) of pure coniferous tree stands are between 81 and 140 years old; 10 percent are older and the remainder are younger. Pure deciduous stands are typically younger, with 65 percent of the trees

being between 41 and 100 years old. Of the remaining age classes, 26 percent of trees in pure deciduous stands are older than 100 years.

The age of mixedwood forests reflects the age range of their dominant tree type. About 51 percent of coniferous-dominated mixedwoods are 81 to 140 years old, whereas 55 percent of mixed deciduous forests are between 41 and 100 years old (Alberta Environmental Protection 1994).

Figure 3.11

Total Area Covered by Different Age Classes of Trees in Alberta, 1996



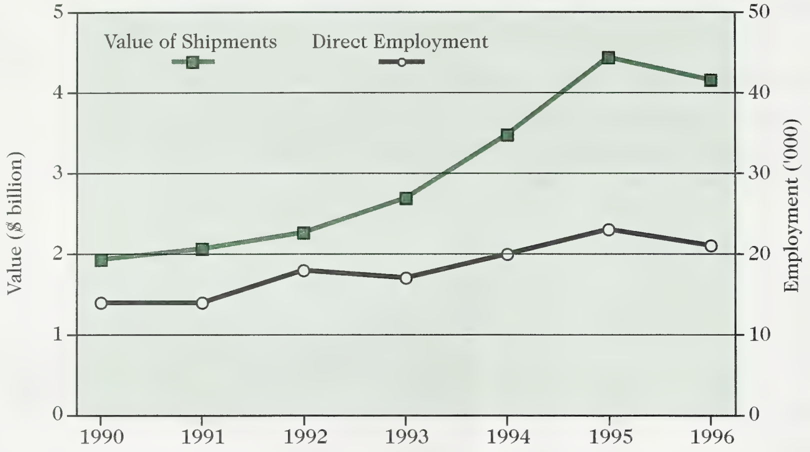
Source: Alberta Environment

Economic Importance of the Forest Industry

Alberta's forestry sector has grown dramatically, and is now Alberta's third largest primary economic sector. Between 1986 and 1994, the provincial forest industry made almost $4 billion worth of new investment in Alberta. The total value of forest industry shipments reached approximately $4.2 billion in 1996. This includes revenue from the logging, wood, paper and allied industries (Canadian Forest Service 1997a) (Figure 3.12). The primary markets for Alberta forest products are the United States, Japan and Europe. Provincial exports of forest industry products to these markets totalled almost $1.9 billion in 1996. Products exported included softwood lumber, wood pulp, newsprint and other products. Value-added input from the manufacturing industry contributed an additional $3.5 billion to Alberta's economy in 1996. Some 21 000 people were employed in the industry in 1996 (Canadian Forest Service 1997b), a substantial increase from 14 000 in 1990 (Figure 3.12).

Figure 3.12

Value of Forest Industry Shipments and Total Number of People Employed by the Forest Industry in Alberta, 1990 to 1996



Source: Canadian Forest Service 1997a

Timber Supply

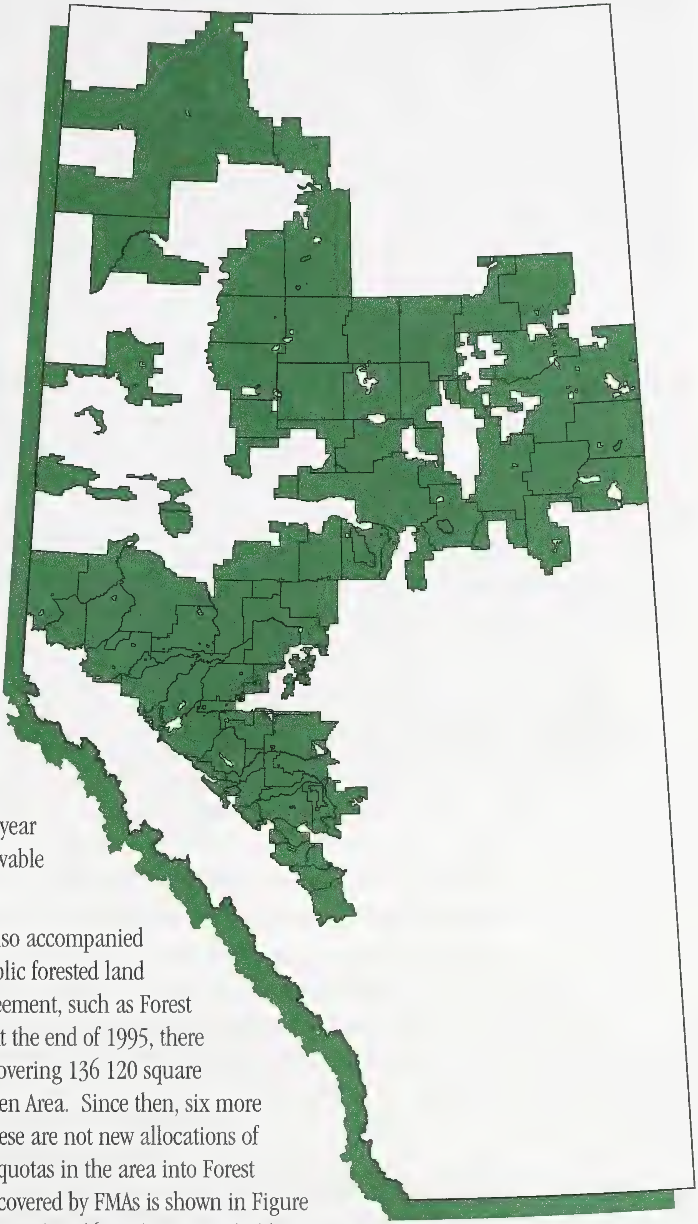
Most of the forested land base in the province is on public land. Productive forests in the Green Area generate an average of 1.98 cubic metres of timber volume per hectare per year (Alberta Environmental Protection 1996b). As indicated earlier, commercially productive forest occupies 22.5 million hectares of the Green Area. Multiplied by the average annual growth per hectare, this means that 44.5 million cubic metres of timber are produced annually on publicly owned productive forest land. However, not all of this area is available for timber harvesting. For example, prime protection areas, steep slopes and buffer strips (around lakes and along river valleys) are left uncut.

Alberta continues to develop initiatives and techniques to manage and protect the provincial wealth of natural resources. Forest Land Use Zones restrict activities, such as motorized recreation, to allow for "soft footprint" recreational and tourism activities. There is also the "Special Places" program that is adding sites to the network of protected areas (Section 3.5.3).

In general, the Alberta government and the forest industry manage the available forests so that they may be harvested once every 80 to 100 years for coniferous trees, and once every 60 to 70 years for deciduous trees. Alberta Environment regulates and controls the timber harvest on provincial public land through an Annual Allowable Cut (AAC). AACs determine the volume of timber that forest companies are permitted to take annually from a particular area over a specified period of time.

Figure 3.13

Existing and Proposed Forest Management Agreements in Alberta, 1997



The method of determining AACs is complex. Calculations are based on estimates of the extent of the forest landbase; tree growth rates; losses to fire, insects and disease; accessibility; environmental considerations; investment in ***silviculture***; and management objectives. The total net AAC in Alberta is about one-half the annual growth volume, or 22.1 million cubic metres per year (58 percent coniferous and 42 percent deciduous). AACs are revised at least every 10 years to reflect changing conditions and improvements in data and knowledge. Revisions occur sooner if sudden changes occur, such as major fires or outbreaks of insect pests or disease. The Alberta government audits timber disposition holders at the end of each five-year period to ensure they are within their allowable cut.

Recent growth of the forest industry was also accompanied by a significant increase in the area of public forested land allocated for harvesting under formal agreement, such as Forest Management Agreements (See sidebar). At the end of 1995, there were 11 Forest Management Agreements covering 136 120 square kilometres — about 40 percent of the Green Area. Since then, six more FMAs have been signed. In some cases, these are not new allocations of timber, but are amalgamations of several quotas in the area into Forest Management Agreements. The total area covered by FMAs is shown in Figure 3.13. In addition to the 17 FMAs, the province has 46 Timber Quota holders and 516 Commercial Timber Permitees.

The Tenure System

The tenure system in Alberta provides the forest industry with a long-term perspective for timber harvesting practices. The system is important in helping ensure that Alberta's forests are harvested in a sustainable manner. The tenure system includes three types of arrangements: Forest Management Agreement (FMA), Timber Quota and Timber Permit.

Forest Management Agreement

An FMA is an agreement between the Alberta government and a company. It allows the company to establish, grow and harvest timber in a manner designed to provide perpetual sustained yield. FMAs are the largest and most comprehensive agreement offered for timber harvesting. Renewable after 20-years, FMAs give a forestry company harvest rights for large areas of commercial timber under strict and specific conditions. A company's harvest and management plans must first be approved by the Alberta government and are revised every ten years. FMA holders are responsible for reforesting the harvested area. FMA holders must also consult the public when developing their forest management plans. This ensures the public has a say in forest resource planning.

Timber Quota

A timber quota gives a company a long-term right to harvest a percentage share of the allowable harvest in a Forest Management Unit. The quota system was introduced in 1966 and was intended to provide a long-term wood supply to small and medium-size timber operators. Outside of FMAs, forest management planning for quota holders is done by the provincial government.

Timber Permit

A timber permit reserves a portion of the allowable cut for local community use and for timber operators who only cut small volumes. Permit holders pay either a reforestation levy or all reforestation costs.

3.2.2 Agents of Change

Agents of change in Alberta's forest ecosystems can originate from natural sources, as well as human activities. Measured by the amount of disturbance, the most important natural disturbances are fire, insects and disease. Some years, the overall area affected by forest fires, insects and diseases is extensive. But these natural processes, active in virtually all of Alberta's forests, are natural agents of change for forest ecosystems. Forest size, shape, distribution pattern and mix of tree species are all affected over time by a combination of climate, landform, and the frequency of fire and other disturbances.

Timber harvesting can also disturb forest ecosystems. As with fire, the changes can be abrupt. Harvesting's potential effects include habitat alteration and fragmentation, a reduction in biological diversity, and soil compaction and erosion. Overall, timber harvesting, fire suppression, and related forest management activities affect the forest ecosystem. In some areas of the province, however, clearing for agriculture and petroleum exploration and development are more significant human disturbances than timber harvesting.

Forest Fires

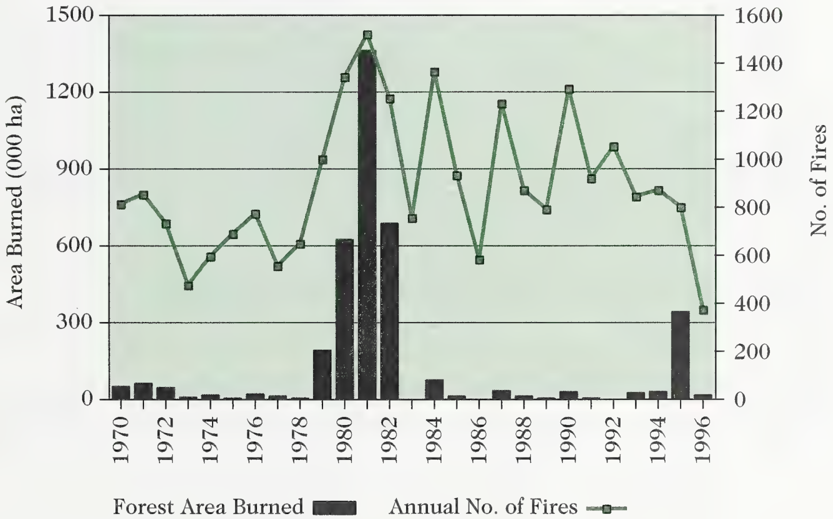
Fire has played a significant role in shaping the forest landscape of Alberta. Fire is a natural process in terrestrial ecosystems, and has occurred since the glaciers retreated. The boreal forest, in particular, is a "disturbance" forest where fire is the predominant agent of change. Forest fires have burned more than 75 percent of Alberta's forest area in the last

50 years. It should be noted, however, that not every fire completely destroys the forest it burns through, nor does every fire significantly damage the trees. Some fires burn mostly the ground cover while others burn only the crowns (tops) of trees. Still others are low intensity fires that cause little damage. This is very typical of forest fires in Alberta - they are quite variable in the degree of disturbance (Murphy 1985).

On average, about 1000 forest fires occur each year in the province. From 1970 - 1996, this resulted in an average disturbance of more than 1400 square kilometres per year (Figure 3.14). In 1981 alone, 13 660 square kilometres of forest burned as a result of 1522 forest fires (Canadian Forest Service 1997a).

Figure 3.14

Number of Forest Fires and Total Area Burned, 1970 to 1996



Source: Canadian Forest Service 1997

Forest fires are caused by human activities, lightning, and unknown factors. Human-caused fires are most often attributed to recreation (such as camping and hiking) and activities around nearby residences and industries (Table 3.2). Although human activities cause a large proportion of forest fires (more than 50 percent in recent years), fires started by lightning strikes usually account for a much greater total area of forest burned. Widespread lightning activity over a one-day period is capable of causing a large number of forest fires. For example, on August 6, 1990, lightning strikes started 109 fires province-wide.

Table 3.2

Frequency and total area burned for forest fires resulting from humans, lightning and unknown causes

Year	Number Of Fires			Total
	Human Caused	Lightning Caused	Unknown	
1990	367	914	15	1296
1991	430	466	27	923
1992	397	626	32	1055
1993	309	517	22	848
1994	356	499	17	872
1995	419	358	27	804
1996	159	217	---	376
Total Area Burned (square kilometres)	210	6087	44	6331

Focus Issue - Fire and Succession in the Boreal Forest

Boreal forest ecosystems continually change as trees mature, die and regenerate. This cycle (referred to as ecological succession) is affected by natural disturbances — diseases, insects and most notably large-scale fires. By killing the trees, these forces shift the forest to an early successional stage with shrubs and grasses adapted to clearings and open areas. Over time, a new forest is established. In the absence of disturbance, the forest reaches the final stage of succession, called the climax community. In Alberta's boreal forests, the dominant species in the climax community are usually white spruce, balsam fir and black spruce.

Fire is a natural phenomenon throughout Canada's boreal forests. Fire plays a significant role in the dynamics of the natural forest — it determines the distribution and growth of forest stands. Few boreal forest stands reach an age of more than 150-200 years. As a result of large forest fires, the boreal forest is characterized by large areas where the trees are all about the same age.

In mixedwood ecosystems, younger stands are composed mainly of early successional species such as aspen, which readily colonizes a burned area. Wetter areas, such as river valleys and areas of higher rainfall, are less vulnerable to the

effects of fire and tend to approximate more of a climax type of vegetation. Old-growth forests of white spruce/balsam fir, the regional climax type, are relatively uncommon in Alberta.

Many boreal tree species are adapted to surviving the effects of fire. Jack pine and lodgepole pine, for example, have cones that do not open without the heat of a fire. Their seeds readily germinate in the mineral soils left after an area is burned. Black spruce regenerates and grows best when fires burn away competing undergrowth and other ground cover, such as leaf litter on the forest floor. Aspen has a different reproductive strategy: if the fire is not too intense, the above-ground tree may be killed, but its roots may survive and produce sprouts. Many mammals and bird species in boreal forests — such as moose and chestnut-sided warblers — require habitats provided by young forests that follow a major fire.

Research is underway to determine how clearcutting can approximate the effects of fire in creating young boreal forest habitats. Many of the same species that establish following a fire can be found in recent clearcuts. Special efforts are needed for timber harvesting to duplicate the irregular patterns and structural elements found in recent burns, such as patches of live trees and abundant dead snags and downed woody material. Retaining these features is vital for species such as bats and woodpeckers.

Insects and Disease

The major forest insect pests in Alberta include forest ***defoliators*** (eastern spruce budworm, forest tent caterpillar) and bark beetles (mountain pine beetle and spruce beetle). The major forest diseases are dwarf mistletoe, wood decay, armillaria root rot and stem cankers.

Insect pests and disease represent a significant disturbance of forests ecosystems in Alberta. From 1988-1992, the estimated average annual growth loss due to major forest insect pests and diseases in Alberta was 7.3 million cubic metres (Brandt 1995). These losses were the equivalent of about one-half of the timber volume harvested in the province during the same period.

Insects

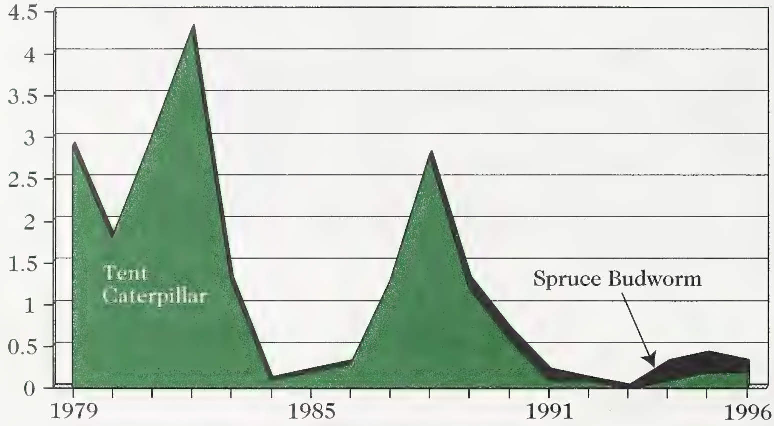
In general, insect pests are fairly host-specific and are mostly associated with older forests. Cycles of insect infestation are natural. Two insect pests that cause the most damage to Alberta forests are the spruce budworm and forest tent caterpillar — both insects cause damage trees by eating the foliage (defoliation). Different levels of defoliation, over various periods of time, can reduce a tree's

growth. If the defoliation is prolonged, the tree may die. Infestations also weaken affected trees, making it easier for disease to take hold.

The extent of growth loss or mortality varies with damage intensity, site condition, tree age, tree health, weather conditions, and the like. Damage from the spruce budworm and tent caterpillar fluctuates from year to year (Figure 3.15). Between 1978 and 1996, these two insects caused moderate to severe damage on an average of 11 700 square kilometres of forest annually. Widespread insect damage may limit the economic use of certain tree species and render areas of forest unsuitable for recreation, wildlife habitat or other uses.

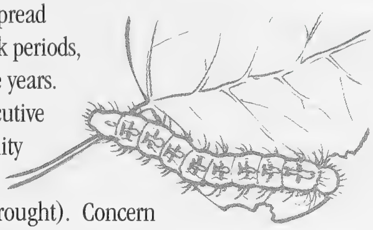
Figure 3.15

Total Area of Moderate to Severe Defoliation by Spruce Budworm and Forest Tent Caterpillars in Alberta Forests, 1979 to 1996



Note: Estimates were made in the Green Area of the Province
Source: Canadian Forest Service 1997a.

The eastern spruce budworm is considered to be the most destructive insect pest of coniferous forests. It is a cyclical pest that has erupted in outbreaks every 20-40 years in this century. The larval stage, or caterpillar, feeds on the young needles of its coniferous tree host. White spruce have the ability to survive prolonged defoliation episodes, but the onslaught usually results in reduced tree growth or sometimes kills the tree or its crown. Balsam fir are more vulnerable to the infestations and often suffer tree mortality (Cerezke and Volney 1995). In recent years, most outbreaks in the province have been fairly localized and confined to major river valleys, such as the Wabasca, Chinchaga, Peace and Athabasca River drainages. The current outbreak in the province was detected in 1987, and at its peak, affected more than 200 000 hectares of white spruce stands.



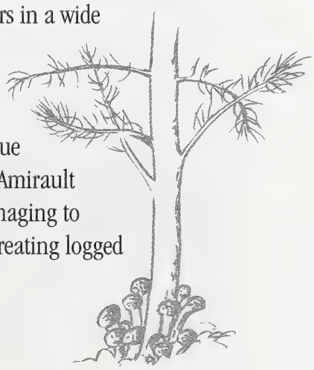
The forest tent caterpillar is the major defoliator of deciduous forests in the province. Outbreaks of this insect usually occur in seven to 10 year cycles. Outbreaks develop initially in the aspen parklands and then spread northward into the boreal mixedwood forest. During outbreak periods, aspen forests often sustain severe defoliation for three or more years. A measurable reduction in growth may occur after two consecutive years of defoliation (Cerezke and Volney 1995). Direct mortality rarely occurs, but defoliation results in reduced growth and exposure of trees to other stress factors (such as disease and drought). Concern for the overall impact of the tent caterpillar on aspen-dominated boreal forests is increasing because of the rapidly expanding use of aspen wood and fibre products.

The mountain pine beetle is a serious pest of mature pines in western Canada, but does not cause defoliation. Instead, eggs laid by female beetles develop into larvae that feed on the ***cambium layer*** under the bark. Infested trees usually succumb to the combined effects of this feeding and the diseases (such as blue stain fungi) that infect the trees during the onslaught — death usually occurs within one year of infestation. Between 1977 and 1987, an outbreak of mountain pine beetle occurred in southwestern Alberta and in the Cypress Hills. During that period, an estimated 3.5 million lodgepole pine trees died, representing a total volume of 1.15 million cubic metres of wood (Cerezke and Volney 1995). Since then, damage has been insignificant, partly because the Alberta government conducts an effective monitoring program to control potential outbreaks.

Diseases

Dwarf mistletoe is a parasitic plant whose host trees are commonly jackpine and lodgepole pine. It attacks trees of all ages, reducing the growth and vigour of the host. In 1994, 54 300 hectares of lodgepole pine and 112 000 hectares of jackpine forests were severely affected by dwarf mistletoe in Alberta (Hall 1996). This resulted in mortality and growth losses of 3.9 million cubic metres (Brandt 1995).

Armillaria root rot is a root decay fungus that occurs in a wide variety of coniferous and deciduous hosts, and is one of the most serious diseases of young conifer stands. Small trees infected by this pathogen are usually killed quickly, while larger trees can continue growing for some time after infection (Moody and Amirault 1992). Because armillaria root rot can be very damaging to regenerating stands, silviculture practices include treating logged areas for the disease before replanting.



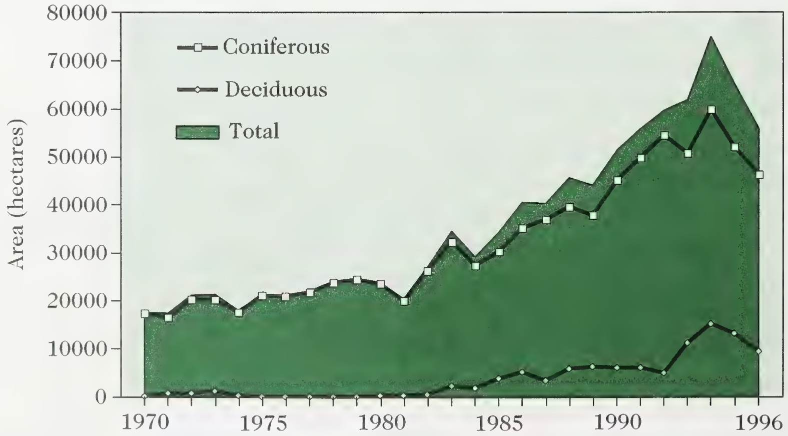
Timber Harvesting

The expansion of the forest industry in Alberta, particularly the pulp and paper and allied wood products industries, has been accompanied by an increase in the number of large forest industry operations. In 1985, Alberta had 19 large sawmills (each producing more than 10 million board feet annually), two pulp mills and five panel producers (Bamsey 1987). Since then, the industry has added nine large sawmills, four oriented strandboard and panel board plants, five new pulp and paper mills and has expanded two others (Clear Lake Ltd. 1995). Further expansion in the industry is planned for the near future, particularly for oriented strandboard and pulp production.

The total volume of timber harvested from public land in Alberta has shown a corresponding increase - from four million cubic metres in 1970 to 20.3 million cubic metres in 1995 (Canadian Forest Service 1997a). This does not include the additional harvest from private lands, which totalled more than three million cubic metres in 1995. The total area harvested increased from 17 600 hectares in 1970 to an estimated 56 000 hectares in 1996, which is approximately 0.25 percent of the productive forest landbase (Figure 3.16). To date, the majority of timber harvesting on Public lands has occurred in the foothills. The increase in harvest in recent years is due largely to the harvest of hardwoods (such as aspen) to manufacture wood pulp, paper and oriented strandboard products (Figure 3.17). Despite the increase, the level of harvest from public owned lands remains below the current provincial Annual Allowable Cut of 22.1 million cubic metres.

Figure 3.16

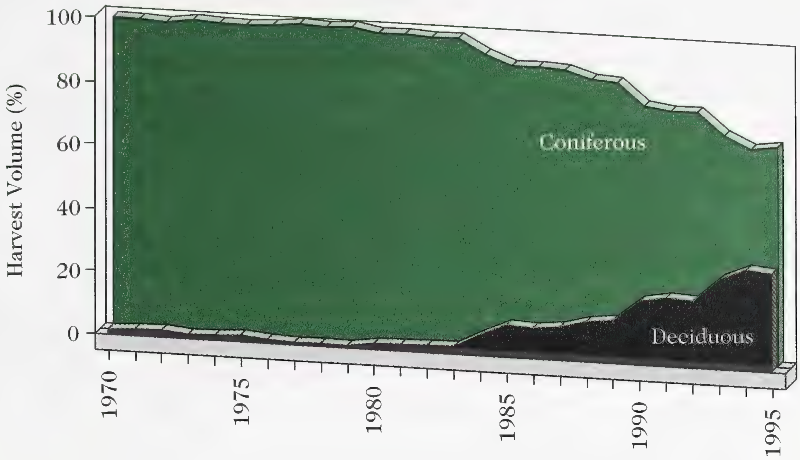
Total Area of Public Lands Harvested in Alberta 1970 to 1996



Note: No 1976 data for deciduous
Source: Alberta Environment and Canadian Forest Service 1997a.

Figure 3.17

Proportion of Annual Timber Harvest Volume Contributed by Coniferous and Deciduous Trees in Alberta, 1970 to 1995



Source: Canadian Forest Service 1997a

Under the new ecosystem management principles practiced by the forest industry (see section 3.2.3), there are provisions for leaving tracts of mature trees. In addition, logging of mature stands is partly offset by improved fire suppression and control efforts by industry and the Alberta government. By incorporating fire suppression with forest management planning, the age class distribution has shifted to an older forest.

Focus Issue - Old Growth Forest

The term Old Growth Forests describes ecological conditions where large trees in the mature stages of their life cycle generally dominate the forest vegetation. The old-growth stage may be reached at different ages depending on the tree species and site condition. At 50 to 100 years old, aspen forests can be dominated by large trees nearing the end of their life cycle. In undisturbed coniferous forests, spruce trees can reach 150 to 200+ years of age.

Old growth forests have a more complex structure than younger stands. This is due largely to the presence of fallen trees, snags, gaps in the canopy, shrubs and ***understory*** vegetation. This structural diversity provides a greater variety of micro-habitats. Consequently, there is a particularly rich diversity of mosses, lichens, insects, and smaller microbial organisms. Many forest species require old-growth stands for part of their life cycle. Examples in Alberta include woodland caribou, fisher, flying squirrel, bats, forest owls and hawks, and a variety of songbirds.

Certain old-growth forests in Canada, with trees hundreds of years old, have become the focus of major disputes regarding appropriate use. Among the most contentious issues are logging versus conservation of the old-growth temperate rain forests of British Columbia, the eastern white pine and red pine forests of Ontario, and the hardwoods of the Maritimes (Government of Canada 1996). Public interest in their conservation centres on old-growth forest ecosystems, with their many unrecorded species and general vulnerability to change. There are also many strong aesthetic, recreational and spiritual values associated with these ecosystems.

Alberta's forests have developed under a history of frequent fire. As a result there are few areas where forests are over 200 years old. Stands of older trees tend to be found in river valley floodplains and areas with a higher moisture regime. Even where older forests are found, light fires may have passed through these stands, burning the understory vegetation.

Over the past century, fire suppression has changed forests in Alberta and other parts of North America, allowing more stands to reach maturity. This also increases the quantity of fuel (deadwood) available to be burned and consequently, it has increased the risk of major, intense forest fires. As an example, in Yellowstone National Park in the United States, wildfires burned 45 percent of the park's area in 1988. Subsequent studies showed that a century of fire suppression had caused an unprecedented shift toward 'old, decaying forest' with huge fuel loads in the park.

Prescribed burning and timber harvesting can be used to reduce the risk of catastrophic fires. The goal is to incorporate natural disturbance patterns into forest management planning at the landscape level to break-up the large, even-aged stands produced after major fires, and reduce the overall fuel load. The resulting forest will feature a variety of forest stages, including areas of old-growth forest.

Method of Harvest

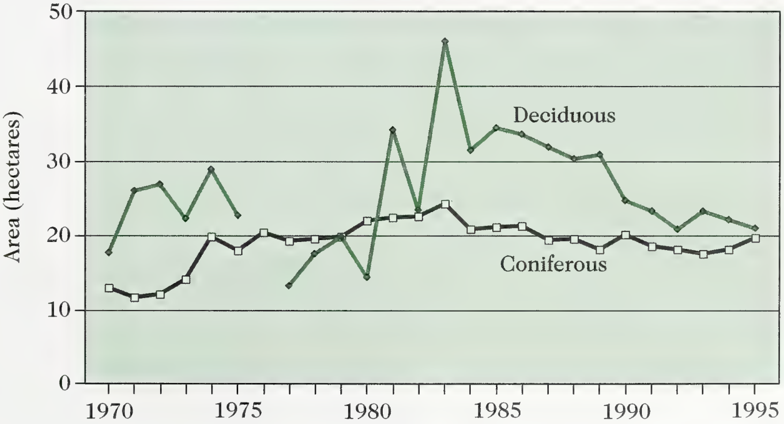
In Alberta, areas designated for harvest are usually cut in two stages, or "passes". In the first pass, one-half of the ***merchantable*** timber is logged using a patchwork pattern designed to fit into the landscape. The pattern alternates between harvested patches ("cutblocks"), and unharvested patches ("leave blocks") of similar size. The leave blocks are harvested in the second stage, 10 to 20 years later when the cutblocks harvested in the first pass are growing well again as new forests.

The seedlings of some tree species (for example, lodgepole pine and aspen) have adapted to open conditions. They regenerate and grow well in the soil and sunlight conditions of cleared areas (similar to the conditions created by forest fires). For this reason, the two-pass system tends to be the most economical and appropriate technique for harvesting these types of forests. Harvesting must be done properly, in accordance with provincial legislation and policy, in order to protect sensitive watersheds and the ecosystems of rivers.

The size of cutblocks varies, but maximum average sizes are given as guidelines by the Alberta government. For spruce trees, maximum cutblock size may vary from 24 hectares to 32 hectares depending on the type of block. For pine and deciduous trees, cut blocks may average 60 hectares and individual blocks may be as large as 100 hectares. Average cutblock size in Alberta over the last three decades has varied from 10.9 to 24.2 hectares for coniferous species, and from 13.2 to 46.0 hectares for deciduous species (Figure 3.18).

Figure 3.18

Average Cutblock Size for Coniferous and Deciduous Trees in Alberta, 1970 to 1995



Note: No 1976 data for Deciduous
Source: Alberta Environment

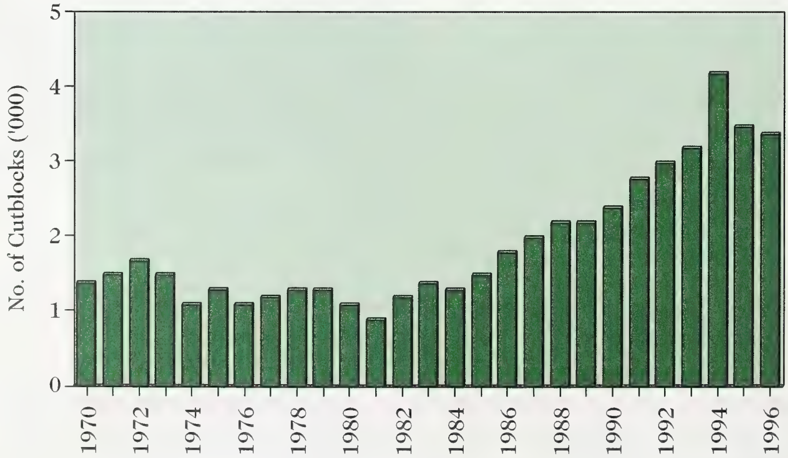
One consequence of clearcutting is habitat fragmentation. Fragmentation can be defined as the subdivision of once contiguous habitats and ecosystems into patches of various sizes and shapes. This type of fragmentation in a forested ecosystem is seen as a patchwork of treed areas and clearings. Timber harvesting may increase or decrease fragmentation, depending on the block size compared to the natural patch size. For example, harvesting within a large, even-aged stand increases fragmentation, whereas harvesting a large, patchy area may later produce a more uniform forest community.

Fragmentation decreases habitat effectiveness for many forest dwelling species (Hobbs and Huenneke 1992, With and Crist 1995). Species requiring large tracts of undisturbed forest for food, cover and reproduction may be less successful in areas where this habitat type remains as patches only. On the other hand, other species of plants and animals will benefit from the large clearings and more forest edge.

During the past couple of decades, the forest industry has tended to use smaller sized cutblocks in most harvest areas. More recently, a wider range of cutblock sizes and shapes have been employed. Although smaller blocks are more aesthetic and beneficial for regeneration of some tree species, they also effectively increase the degree of habitat fragmentation. Between 1966 and 1996, there were 51,700 coniferous and 4,500 deciduous blocks cut in Alberta (Figure 3.19) over an area totalling one million hectares. These numbers represent a certain amount of habitat fragmentation in harvest areas with associated cutblocks and leave blocks. However, there are other factors that contribute to fragmentation in forested areas, including clearing for agriculture, energy exploration, building roads, urban expansion, and so on. Habitat fragmentation is a complex issue, and the forest industry is continuing to experiment with different types of cutting methods that will reduce the effects of fragmentation.

Figure 3.19

Number of Coniferous and Deciduous Cutblocks in Alberta, 1970 to 1996



Source: Alberta Environment

Focus Issue - Neotropical Migratory Songbirds

Neotropical migrants are birds that overwinter in the tropics but visit Canada and the United States during our summer, in order to breed and raise their young. About 60 percent of Alberta's 260 breeding birds are neotropical migrants (Thomas 1994). These are represented by 35 different bird families — the majority are perching birds, or songbirds — of which 40 percent are forest-dependent during the nesting season. Some of the better known neotropical migrants in Alberta include ruby-throated hummingbird, northern oriole, tree swallow, Eastern kingbird, western tanager, yellow warbler and a large number of other wood warblers. Neotropical migrant birds travel north to temperate forests for two basic reasons: (a) an abundance of food (especially insects) and (b) the availability of habitat for nesting. In Alberta, these forests provide habitat for a wide variety of birds. Canadian Breeding Bird Survey data indicate that the Boreal Forest and Aspen Parkland contain the highest number of nesting bird species of any western Canadian natural region (Downes and Collins 1996). In the fall, these birds migrate to the tropical forests of Mexico, Central America and South America.

The ecology and conservation of neotropical migrants, on both their wintering and breeding grounds, has been the focus of much research lately because the populations of many species are showing serious declines (Finch 1991, Hagan and Johnston 1992). For most of the forest-dependent species, habitat loss has been identified as the critical problem. According to Terborgh (1989) about one-half of all neotropical migrants winter in the countries of Mexico, Cuba, Haiti, Dominican Republic and Bahamas. These countries, and many others in Central and South America, have undergone recent rapid deforestation of their tropical forests.

For many neotropical migrant songbirds, there is also concern over the effects of habitat loss and fragmentation in temperate forests.

Neotropical migrant songbirds are considered to be useful indicators of the ecological well-being of the international forests they inhabit, but research has been limited. Recently, Alberta forest industries began conducting research on the habitat requirements of many of these species. These data will by used to develop better forestry practices and ecological management plans that will address the needs of all forest-dependent species.

Increased Access

The harvesting of timber resources involves constructing temporary or permanent access routes. As is often the case in Alberta, however, access roads may have been built previously for exploration and development of petroleum and natural gas resources. Improved access routes into the forest can benefit people other than industry, particularly recreationists such as off-highway vehicle enthusiasts, hunters, anglers, and campers. Both controlled and uncontrolled access into previously inaccessible areas can be harmful to some components of the forest ecosystem. Uncontrolled access to vehicular traffic, in particular, can lead to symptoms of overuse. Soil compaction and erosion, damaged vegetation on sensitive terrain and around watercourses, are examples of these symptoms.

Sometimes industry roads create access into areas with sensitive wildlife habitat, perhaps a critical overwintering area for large game. Other wildlife species are vulnerable because of their specific habitat requirements. Many of the larger carnivores (e.g., bear, wolf, and cougar), for example, are less tolerant of the inevitable human intrusions that accompany improved access, and tend to avoid these areas. When use by people increases, the usual result is reduced habitat effectiveness for these types of species. When use by people is minimal, some species (e.g., wolf) may take advantage of an access corridor as a travel route. In addition, improved access and increased use of an area usually increases the risk of human-caused forest fires. Finally, there are social impacts that affect traditional land uses, and wilderness and heritage values.

To address these and other access management issues, the Alberta government establishes limitations on recreational use and access in environmentally sensitive forest areas (see section 3.2.3). As well, industries working in the forest recognize the impacts associated with access and are taking steps to reduce these impacts. Strict controls and planning processes are also in place to minimize impacts and protect the environment.

Use of Pesticides

Two main types of pesticides are used in forest protection and management: insecticides for insect control, and herbicides for control of competing vegetation in reforested stands.

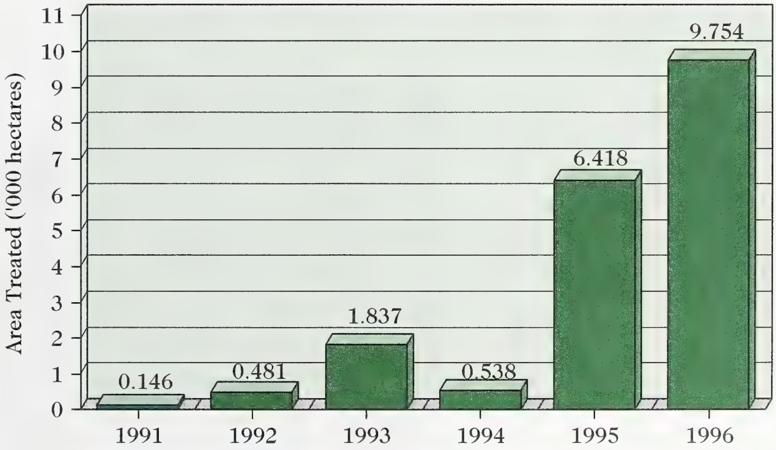
Historically, conventional chemical insecticides have been widely used in parts of Canada to control forest insect pests (for example, to control spruce budworm in eastern Canada). In Alberta, however, these insecticides have not been used on a major scale in forested areas. Currently, Alberta uses two types of biological insecticides to control forest insect pests: biological-based products (for example, *Bacillus thuringiensis*); and biochemical-based products such as insect growth hormones and ***pheromones***.

Herbicides are one silvicultural tool that may be used to manage forest vegetation to achieve specific forest management goals. These products have proven to be an effective, cost-efficient means of managing vegetative competition in reforested coniferous cutblocks. The large-scale application of herbicides is a relatively new practice in Alberta forests (Figure 3.20).

In Alberta, the provincial government supports the responsible use of herbicides for forest vegetation management in accordance with provincial and federal legislation and provincial guidelines ("Guidelines for the Use of Herbicides for Silviculture in Alberta"). According to Alberta's guidelines, herbicides can be used to reduce competition from non-crop vegetation (grass, shrubs, and in some cases, deciduous trees) during site preparation and stand tending operations. The objective is to establish and maintain or improve the growth of desired tree species.

Figure 3.20

Application of Herbicides in Alberta Forests, 1991 to 1995 (2,4-D, Glyphosate, Hexazinone, Triclopyr)



Source: Canadian Forest Service 1997a.

All forest vegetation management practices, including herbicide use, are determined both by forest management objectives (such as, wildlife, recreation, watershed, grazing), and by the vegetation management options available to meet those objectives in an environmentally sound manner.

Harvesting on Private Lands

In recent years, there has been a significant increase in the amount of timber harvested on private land in Alberta (Figure 3.21). The amount of timber harvested from private lands in 1994 and 1995, a total of 7 350 000 cubic metres (Canadian Forest Service 1997a), accounted for more than 18 percent of the

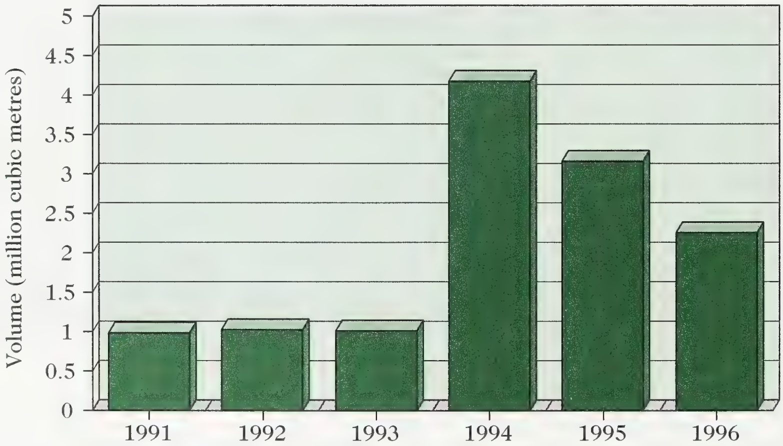
provincial total in those two years. Depending on the average yield per hectare, this harvesting represents a total area somewhere between 25 000 and 30 000 hectares.

Why was there a sudden increase? Alberta forestry companies, and others from outside the province, offered good prices for timber. With a growing scarcity of commercial timber supplies in B.C. and Montana, Alberta's privately owned timber suddenly became a valuable commodity. This was particularly true when some of the non-resident logging companies offered to pay landowners two or three times the Alberta price for their trees (Nikiforuk 1994). Much of the logged private land was then converted to agricultural use, such as livestock grazing, rather than establishing a sustainable woodlot operation.

To date, most logging on private lands has occurred along the eastern foothills, in the Peace River region, and in the Whitecourt and Lac La Biche areas. Many of Alberta's FMA and Timber Quota holders must continue to meet their demands by purchasing timber outside of their disposition area.

Figure 3.21

Volume of Industrial Roundwood Harvested from Private Land in Alberta, 1991 to 1996



Source: Canadian Forest Service 1995 and 1997a.

Although most landowners are generally good stewards of the land, harvesting timber on private lands is not without its ecological risks. This is particularly true for private lands that are not managed as private woodlots for timber production. Most of the regulations governing logging practices on public land in Alberta do not apply to private land, however, some environmental legislation does still apply; Alberta's *Soil Conservation Act*, the *Water Act*, the *Environmental Protection and Enhancement Act* and the federal *Fisheries Act*.

3.2.3 Actions

Forest Policy

The demands on Alberta's forest ecosystems are increasing, and a new strategy for conserving and managing these important resources is required. In response to this need, the Alberta government facilitated the development of the Alberta Forest Conservation Strategy in 1994. It was completed and submitted to Government in 1997. The multi-stakeholder steering committee consulted with more than 800 Albertans to develop a long-term vision and recommendations for our forests. The Alberta Forest Conservation Strategy aims to guide the future use and appreciation of the province's forests. The main goal of this initiative is as follows: "to maintain and enhance, for the long-term, the extent and health of forest ecosystems in Alberta for the sake of all living things locally, provincially, nationally and globally, while providing environmental, economic, recreational, social and cultural benefits for present and future generations."

Early in 1998, the Alberta government announced its new forest policy: the Alberta Forest Legacy. It was built on recommendations in the Alberta Forest Conservation Strategy, as well as previous recommendations by the Alberta Roundtable on the Environment and Economy, and the 1990 Expert Panel on Forest Management. All of these initiatives included broad public input and stakeholder involvement.

The Alberta Forest Legacy supports the principle of adaptive management, to move forward in an experimental, informed and continuously improving fashion. It outlines new directions for land management in Alberta, expanding the focus to the broader landscape and encouraging Albertans to consider all resource values related to forest management decisions. The document recognizes different intensities of forest use, ranging from wilderness preservation to economic development. It adopts a number of principles and practices, including ecological management, effective public involvement, and exercising caution when the consequences of actions in the forest are uncertain.

Forest Management Planning

Good planning is an essential part of effective management. On Forest Management Areas, FMA-holders are responsible for developing Detailed Forest Management Plans that consider both timber and non-timber vales and involve the pubic. Outside of FMAs, the provincial government retains forest management planning responsibility.

In early 1998, Alberta's Interim Forest Management Planning Manual came into effect, implementing many of the broad policy directions of the Alberta Forest Legacy. While clearly setting the government's expectations for the results of forest

management planning, the manual provides a high degree of flexibility to industry to achieve those results. Unlike some other jurisdictions in Canada, the province makes no claim to have all the answers, and supports innovation by industry leaders, an application of the adaptive management philosophy on a large scale.

Ecological Management

Historically, public forested lands in Alberta were managed on a sustained yield basis, with a greater emphasis on timber use and values. The term sustained yield was defined as "management of forested land for continuous production with the aim of achieving a balance between net tree growth and harvest". Sustained yield management also means that coniferous, deciduous and mixedwood forest would be maintained in about the same proportion as they now exist in perpetuity (Alberta Environmental Protection 1994).

The idea of sustained yield management has shifted toward the broader approach called ecological management. Ecological management recognizes that Alberta's forests were created by disturbance regimes and that a balance of natural and human disturbances will be required to maintain forest biodiversity in the future. Using an ecological management approach, Albertans must plan their activities on forest lands so they do not interfere with the ecosystem's ability to perpetuate itself.

Ecological management is an evolving approach that focuses on ecological processes and ecosystem structures and functions, while sustaining the types of benefits that people derive from the forest. This approach acknowledges the importance of all species and the processes that support them in the soil, water and air. It recognizes that ecosystems occur across the landscape, and the interconnections between forest ecosystems, the economy and society. Ecological management is based on the following concepts: maintaining the forest landbase, operating within the range of natural variability, using an adaptive management approach, changes in practices, and better forest planning.

The move to ecological management is a continuous process. Human activities (like timber harvesting) are sometimes carried out in such a way that their effects resemble those of natural processes. Today, cutblocks often have irregular sizes and shapes, and follow certain features of the landscape. Forest industry companies often do studies of watersheds, wildlife habitat, and the ecological effects of timber harvesting, to name a few. Forest management will continue to move toward ecological management in the future. Forest management has to build on the knowledge we gain from forest ecosystems, adapting to new information. Ecological management will be a guide for us to help ensure that forests will continue to exist for the future.

Forest Protection

Fire is a natural element in the forest ecosystem, and many of the positive effects of fire have been recognized. However, the net effect of wildfire is negative for timber production, recreation, traditional uses, and some species of wildlife. The reduction of losses to wildfire is a key timber management goal in Alberta, and an important consideration in determining sustainable yield and Annual Allowable Cut.

Alberta Environment has a major program for fire prevention, detection and suppression. The forest industry is required to provide supplemental support in the form of equipment, training and personnel. In addition, the forest industry is assessed an annual per-hectare fee for protection. Principal fire management program activities include prevention, detection, pre-suppression (preparedness, initial attack, and hazard reduction), and suppression.

Since 1987, fire fighting expenditures have increased with a greater commitment to control and suppress forest fires. Most of the fire suppression efforts are targeted at the smaller fires to prevent them from becoming large, more costly fires. For example, of the 342 000 hectares that burned in 1995, two fires (from a total of 804) accounted for about 240 000 hectares and three others accounted for about 10 000 hectares. Budgeted expenditures for forest fire control in Alberta have increased significantly from just over $3 million in 1970 to more than $35 million in 1995 (Figure 3.22).

Figure 3.22

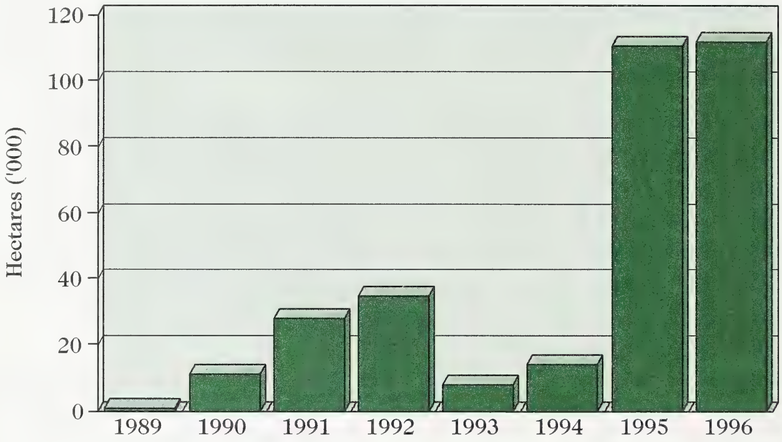
Fire Control Expenditures Budgeted in Alberta, 1970 to 1996

Source: Canadian Forest Service 1997a

Alberta also has successful monitoring and control programs for outbreaks of insects and disease in forested areas. These programs have allowed the province to have better control over infestations, and ultimately reduce timber losses. Protection of forests from insects and disease is important to maintain timber productivity and overall forest health. Instead of chemical insecticides, Alberta uses a biological control agent to fight outbreaks of spruce budworm. The agent is a bacterium, called *Bacillus thuringiensis* that attacks the insect pest. Alberta has had good results with this biological insecticide, and its use is becoming more widespread (Figure 3.23).

Figure 3.23

Total Forest Area Treated by Insecticides in Alberta, 1989 to 1996



Source: National Forestry Database 1997a

The Canadian Forest Service, in collaboration with industry, is involved in research on a new biochemical called "Mimic" (tebufenozide) to control spruce budworm. Mimic was used in 1997 on a forested area infested with spruce budworm. Initial surveys indicated that the insecticide worked well on the target insect, however, more research is needed to determine if it can be used operationally.

Forest Inventories

Proper forest management practices can only be implemented if land managers have accurate information on the location, extent and condition of forest resources and the ability to analyze those data to determine the potential effects of different activities. That information must come from appropriate forest inventories. Forest inventories give us important information to help calculate

the Annual Allowable Cut. Inventories provide data on tree age, tree height, what plant species are present, and how much a forest will grow and how fast.

Alberta's Phase 3 Inventory has been one of the most widely used inventories by the provincial forest industry. Its main focus is timber production. It has been kept up-to-date to include forest impacts, such as burned areas, timber harvesting, and land clearings (well sites, pipeline rights of way, agricultural expansion).

In the near future, a new inventory — the Alberta Vegetation Inventory (AVI) — will be completed and will replace Phase 3 . This new inventory is designed to provide information on other forest resources besides the trees to facilitate integrated, ecologically based resource management. Initiated in the mid-1980s, the AVI has some of the same features as Phase 3, but in more detail. It provides better information on artificial features (roads, pipelines, wellsites, etc.), vegetation height, species, crown closure, age and productivity. In keeping with the new direction of forest management, AVI also includes information that was not used in past inventories. Some examples of this are soil moisture, waterbodies (streams, rivers, lakes, etc.), and land elevation. This information is turned into digital computer data and stored in a database to help manage forests. These data can be used in a geographical information system (GIS) to enable more sophisticated resource analysis and to produce maps for many different themes.

The Alberta Vegetation Inventory is being completed by both government and the forest industry. This methodology was formally adopted by the Alberta government and FMA holders in 1991 as the provincial minimum standard for forest inventories. AVI will be the basis for new forest management plans that address both timber and non-timber values, and provide for sustainable development of our forest resources. At the end of 1996, 164 188 square kilometres of forest had been inventoried using this system. AVI is scheduled for completion over most forested lands by the year 2005.

Ground Rules

All forestry companies harvesting trees on public land must operate according to Alberta's Timber Harvest Planning and Operating Ground Rules. The Ground Rules include forest management principles and how to conduct timber harvesting and reforestation responsibly. FMA holders usually negotiate Ground Rules that are specific to their area. However, as an absolute minimum, these rules must meet the standard of the provincial Ground Rules. In summary, the Ground Rules include:

- How to correctly plan timber harvesting
- How to harvest according to government-specified management standards

- How to protect rivers, streams and lakes from possible environmental damage
- How to reduce the problem of soil erosion
- How to develop access roads with as little disturbance to the environment as possible
- How to consider other forest values, like fish, wildlife, recreation and grazing
- How to complete successful reforestation

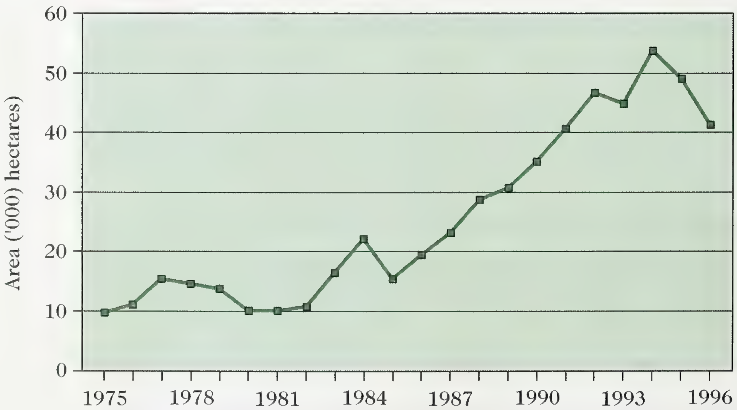
Reforestation

Reforestation has been the law in Alberta since 1966. Under legislation, a forestry company must "treat" a harvested area within two years of logging. "Treatment" means ensuring either natural regrowth or artificial reforestation. With natural regrowth, or regeneration, a timber company ensures that conditions are right for trees to grow back naturally. This means making sure that existing trees produce adequate viable seeds; or in the case of aspen, that conditions are favourable for sapling regeneration from roots. It also means making sure that the seeds and very young trees have the proper conditions to survive and grow. Currently, about 20 percent of the total harvested area in the province is regenerated naturally.

Artificial reforestation is accomplished by replanting seedlings, or by direct seeding. The type of reforestation treatment and activity is determined by the species harvested as well as numerous site conditions. Replanting efforts have improved considerably in recent years, both in the methods used and the quality of the seedling stock. Today, replanting accounts for about 60 percent of the area harvested annually. Direct seeding typically accounts for 20 percent of the total area harvested. The total area treated using these techniques continues to increase (Figure 3.24).

Figure 3.24

Total Area* of Forest Replanted and Reseeded, 1975 to 1996



* Public lands only
Source: Canadian Forest Service 1997

Following replanting, direct seeding or natural regeneration, the area must be surveyed according to provincial standards. The surveys are done at specific time to check for the types of species that are growing, tree density, stocking and tree health, or vigour. The establishment survey is completed four to eight years after harvest for coniferous and mixedwood sites, and three to five years for deciduous sites.

A second survey, the performance survey, is completed eight to 14 years following harvest, on coniferous and mixedwood sites. This survey indicates how well the new trees are growing and identifies areas where the growth of trees is being slowed by competing vegetation. Trees must reach specified heights and no longer face competition from other vegetation to be considered "Free to Grow". When a performance survey reveals areas where there are too few trees or where trees fail to meet height requirements, the site must be retreated. This treatment could mean planting seedlings or clearing away competing vegetation, such as grasses, shrubs or trees. The reforestation success rate in Alberta is generally above 92 percent for coniferous, deciduous and mixedwood areas.

Investing in Forest Resource Improvement

Until 1997, forestry companies were required to pay part of their stumpage fees to the Forest Resources Improvement Program. As of September 1, 1997, this program was replaced and delegated to the new Forest Resource Improvement Association of Alberta (FRIAA). The objectives of the association, as set out in its regulations, include the establishment of programs and initiatives that enhance the forest resource of Alberta; the promotion of enhanced management and sustained yield of the forest; and the promotion of improved integrated resource management. Forestry companies must still fulfil their legislated commitments to reforest harvested areas, but FRIAA will support additional programs for general research, inventory, enhanced silviculture programs and other activities.

Enhanced Forest Management

The portion of Alberta's forest lands designated for commercial timber production - the industrial forest land base - is under increasing pressure. Alberta's vast forest resources must satisfy many needs expressed by society, both now and in the future. To meet these needs, management strategies must maintain forest ecosystem health and biodiversity, and support a competitive forest industry. Enhanced forest management (EFM) on portions of the industrial forest land base provides a means for maintaining or increasing timber supply and the economic benefits derived from timber production on a sustainable basis. Enhanced forest management is undertaken to increase the productivity of stands above that of unmanaged stands or stands managed to meet basic forest management standards. EFM involves silvicultural activities that increase the

growth of stands, such as juvenile or commercial thinning, introducing and managing exotic species, tree improvement, and fertilization.

Access Management

As the demands for industrial, recreational and rangeland use of the forest landbase increases, the need for responsible resource use and access management becomes even more important. Managers of Alberta's forests have shown that limiting access in sensitive areas and designating areas for specific activities are effective in balancing the demands of resource use and protection. As an example, the Alberta Government has established limitations on recreational use and access in environmentally sensitive forest areas in the Eastern Slopes. These areas have been designated as Forest Land Use Zones, under the authority of section 46 of the Forests Act.

A forest land use zone is an area of land to which legislative controls are applied to solve and prevent specific land use problems, such as uncontrolled access. A forest land use zone can be used to (1) protect areas containing sensitive resources such as vegetation, soils, wildlife habitat and watersheds; and (2) separate or control conflicting recreational activities. There are various levels of control that can be achieved through this designation, including:

- Complete exclusion of motorized and /or non-motorized activities, including recreational, industrial and commercial
- Restriction of motorized activities to designated trails or travel corridors
- Exclusion of motorized and non-motorized activities from certain highly sensitive areas within a zone
- Authorization of motorized and/or non-motorized activities during certain seasons

Access is also controlled in parks, other protected areas and in recreation areas

A Research Network for Sustainable Forest Management

In 1995, a network of research in sustainable forest management was established at the University of Alberta - the Sustainable Forest Management Network of Centres of Excellence. Its mission statement is: 'to conduct applied research directed toward forest planning and management, in order to preserve the ecological variability and biodiversity of Canada's forests and sustain its resources for future generations, while maintaining the nation's forest-based economy.' The purpose of the network is to carry out relevant research that focuses on the sustainability of Canada's boreal forests in all their physical, biological, ecological and economic dimensions. This protocol and the associated strategies and environmental technologies that result from Network research will be marketed world-wide.

The Network links scientists in engineering and the biological, ecological and social sciences at Canadian universities with researchers and forest managers in industry, government, and non-government organizations across the country. These comprehensive links will help develop new strategies for forest management, new environmental technologies, and new institutions to ensure that Canada's boreal forest is effectively managed and sustained. The Network research program has four themes:

- Ecological Basis of Sustainable Forest Management
- Minimal Impact Techniques for Forest Materials Processing
- Socio-economic Sustainability
- Planning and Practices for Sustainable Forest Management

There are many studies being conducted in Alberta. Some of these include: fire and tree population dynamics; ecosystem management emulating natural disturbance, nutrient cycling; landscape structure and biodiversity; wildlife habitat and landscape ecology; watershed disturbances and water quality; treatment of pulp and paper mill waste water; economics of sustainable forestry; and sustaining boreal forest First Nations communities.

Southern Rockies Landscape Planning Pilot Project

Alberta Environment is leading a landscape planning pilot project, a collaborative effort also involving Alberta Resource Development, Agriculture, Food & Rural Development, and Economic Development. Its purpose is to develop and test computer simulation models that use science to compare and evaluate planning scenarios at regional and landscape scales. Resources and variables to be modelled include timber, fire risk, fisheries, wildlife, grazing, energy exploration and development, hydrology, visual quality, recreation and tourism. It is expected that these models will be useful in future management planning efforts, both within the study area and elsewhere in the province.

This project supports directions contained in the Alberta Forest Legacy and the Interim Forest Management Planning Manual. Using science to plan at a landscape and larger scales is a fundamental component of ecological management.

The project uses a geographical information systems (GIS) environment, allowing maximum use of digital data, such as Alberta Vegetation Inventory and Base Map data. Complex model calculations to be quickly carried out on various scenarios, and a variety of maps and other visual output displays to be produced for communication with the public and with decision-makers.

This is the first full-scale opportunity within the Alberta government to use GIS technology to support integrated land-use decision-making. The pilot project will be completed in 1999.

Research on Riparian Buffers

Scientific research indicates that riparian forests, treed areas around lakes and streams, may play key roles in maintaining the integrity of terrestrial and aquatic ecosystems. By intercepting the movement of water, they may protect adjacent aquatic habitats from excessive inputs of water, nutrients and sediments. Forest harvesters in Alberta currently leave an uncut strip (riparian buffer) of between 30 and 100 metres bordering permanent lakes and streams. Research is underway to better determine the most effective buffer widths.

Terrestrial and Riparian Organisms, Lakes and Streams (TROLS) is an interdisciplinary research project based at the University of Alberta in Edmonton. The program receives joint funding from both the private and public sectors, including Alberta Environment and a number of forest industry companies. The groundwork for this initiative began in 1993, and field sampling will continue until late 1999. TROLS will examine how riparian buffer strips of differing widths affect plant and animal communities in riparian and aquatic habitats around lakes and streams in northern Alberta. The end result will be a set of recommendations on the minimum riparian buffer strip width and/or watershed harvest intensity required to prevent major changes in aquatic and riparian terrestrial communities. This will further contribute to sustainable forest management in Alberta.

Alberta Forest Management Science Council

The Alberta Forest Management Science Council is comprised of nine academic scientists from western Canada. The Council has expertise in biodiversity management, silviculture, industrial processing, water quality, policy and planning and wildfire management. The Council was put in place in 1996 to advise the department on the transition from contemporary forest management to sustainable forest management. This transition is a commitment of the Alberta Forest Legacy.

The Alberta Forest Management Science Council has completed the first phase of its work. The Council has provided the department with a new timber supply protocol for sustainable forest management. The protocol has five elements including Ecological Integrity and Inherent Disturbance, Desired Future Forest, Social and Economic Values and Public Involvement, Scales (Spacial and Temporal), and Adaptive Management. The protocol has been internationally reviewed and is currently being assessed as a template for forest management in the province.

The Council has recently elaborated on their Desired Future Forest element of the protocol in a report also received by the Minister.

Woodlot Management on Private Lands

The provincial government has recognized the potential for timber harvest on private lands. It has developed an education program in consultations with landowners and other stakeholders, aimed at landowners who wish to manage their treed areas as woodlots. A number of publications have been made available by the Alberta Government, and were produced in conjunction with the Canada-Alberta Partnership Agreement in Forestry and the Canada-Alberta Environmentally Sustainable Agriculture Agreement.

Introduced in 1994, this awareness program gives private landowners information about the economic, ecological and social benefits of properly managed woodlots. The program is designed to accomplish the following objectives:

- Show private landowners the benefits of making long-term management decisions for their land
- Give landowners economic and environmental choices that go beyond one-time liquidation of their timber
- Make contacts with landowners and hold workshops and seminars across the province. Demonstration woodlot tours have been made available
- Extension courses are now available through a number of rural and community colleges

As landowners increase their awareness of sustainable management, they are becoming more selective in the types of management choices they area making. Overall, woodlot education is proving to be an effective way of minimizing the potential for environmental degradation. The Woodlot Association of Alberta now is responsible for providing technical advice and support to its members.

3.2.4 Future Directions

Increase in Area Disturbed

Human population increase and pressure for economic growth will likely put greater demands on Alberta's forest resources. The combined effects of natural factors, primarily fire, and human activities, such as timber harvesting and development of oil and gas reserves, will result in an inevitable increase in the area disturbed.

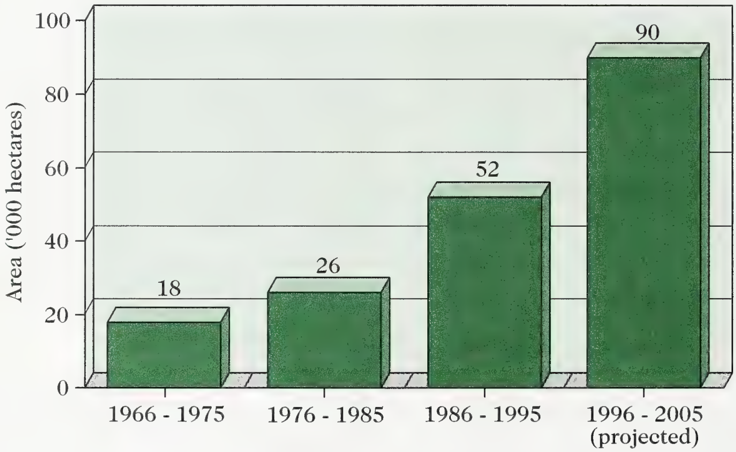
Today, fire, logging and oil and gas activity are the major agents of change in Alberta's forests and this will likely increase in the future. The prevalence of fire may increase over the next several decades as human activity in the forest

increases (and hence, human-caused fires) and if predictions that global warming will cause increased forest fire activity are true. Industrial activity is very much affected by short-term economic conditions, yet some trends are evident. For example, logging activity is on the increase as some of the recently built pulp mills and saw mills are still not up to their full production capacity and some proposed expansions and new mills are not yet operational. Based on current harvest rates and methods, favourable markets and the planned growth of the forest industry, harvesting activity in the decade from 1996 to 2005 may increase by over 70 percent from the previous decade (Figure 3.25). This rate of increase will not continue indefinitely. A new sustainable level will be established once the new operations are in full operation.

Figure 3.25

Past and Projected Area of Timber Harvested Annually

(Presented as an Average for Each Ten-Year Period)



Increased activity is also expected in the oil and gas industry. Oil sands development is expanding in the boreal forest and the eventual decline in conventional oil reserves could lead to increased exploration effort to discover new deposits and to re-assess known deposits that had previously been uneconomic to develop.

Many government and industry programs are already in place to deal with this increased activity in the boreal forest and further adjustments may be needed as the future unfolds. Adaptive Management is a new approach being implemented to continuously evaluate and adjust our management methods.

Alternative Methods of Logging

Historically, clearcutting has been the preferred method of logging in Alberta. This is the most efficient way of harvesting even-aged stands that develop after fire and it encourages natural reforestation by some tree species, such as jack pine. Selective logging can be used on some stands, however this sometimes increases the risk of blow down. Using small-patch clearcutting with feathered edges around the cutblocks allows logged areas to better blend in with their surroundings and viewscapes. Large clearcuts may still be considered, as natural patterns of disturbance are included in forest management planning.

Logging equipment is continually improving. Smaller, more maneuverable machines are being used to cut and handle the trees. Soft tires reduce soil disturbance. Horse logging will continue on a small scale where it is practical for the site and knowledgeable horse-logging operators are available.

Blow Down

Trees that grow up in the shelter of a dense forest can blow down if exposed to strong winds. Logging methods that thin a stand of trees too much or leave small, exposed groups of standing trees can increase the risk of blow-down.

Increasing the Timber Supply

Given the changing demands on forests and the need to manage this resource in a sustainable manner, can Alberta's current level of harvest be maintained or increased? One way to increase timber supply is through enhanced forest management, which includes weeding, thinning, fertilizing and a greater reliance on planting genetically improved trees. All of these activities are aimed at improving the survival and growth of regenerating commercial tree species. Intensively managed plantations could provide higher volumes of timber per hectare than natural forests, and require less land to produce a given volume of wood. However, these silviculture treatments are expensive and would only be cost-effective on the most productive sites near mills.

Although more intensive forest management could lead to an increase in allowable harvest levels, many companies are reluctant to make this investment on land they do not own without a long-term guarantee of the right to harvest the trees grown. Alberta is trying a new arrangement with companies holding forest management agreements, allowing the flexibility to harvest any additional timber that results in an increase in their silviculture investment. Intensive silviculture presents some challenges for ecological management of forests because it relies on more human intervention and greater use of plantations, fertilizers and herbicides. Several forest industry companies are conducting research and trials to find the best methods to increase timber supply in some areas, while managing extensive areas as forest ecosystems.

Genetics and Tree Improvement

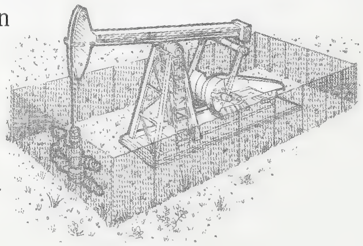
It is not expected that the land base of today's productive forest will increase. There are, however, ways to increase the amount of timber produced by our productive forests. One of the areas where research is vigorously pursued is the

development of genetically improved trees for more rapid reforestation. The science of forest genetics is the study of hereditary variations in trees. Alberta began a genetics and tree improvement program in 1976. Today there are 12 seed orchards and a large number of well-established research trials. Four seed orchards are planned for the future.

Genetically improved trees will be used in future reforestation programs. Comprehensive genetic tree improvement and improved seed production programs are currently in place for the major conifer species. In time, tree geneticists expect to develop trees that are thicker, taller and straighter than today's trees. They will accomplish this through selection, cross-breeding and propagation techniques. Improved reforestation stock is planted to establish new forests that will produce more wood of better quality, and in less time. Initial expectations are that improved seed will bring timber yield increases of five percent for white spruce, and 10 percent for lodgepole pine. Over the next few decades, advanced tree varieties will be developed with increased pest resistance, climatic hardiness, and timber yield increases that may be in the range of 20 to 40 percent.

3.3 Non-Renewable Resources

In Alberta, hydrocarbons — conventional oil, oil sands, natural gas, coal — and sand and gravel are the principal non-renewable resources. Of these, hydrocarbon exploration and production is one of the strongest influences on the provincial economy and environment. Oil and gas exploration in particular, and their development and transport, are widespread and have occurred in every natural region in Alberta (Figure 3.26). This section of the report describes how non-renewable resource development affects Alberta's terrestrial ecosystems, and discusses initiatives now underway to minimize those effects.



3.3.1 Present Conditions

Alberta possesses massive energy reserves in the form of oil, natural gas and coal — about 70 percent of the energy produced in Canada from hydrocarbon reserves comes from Alberta. The province contains about 83 percent of the country's

Figure 3.26

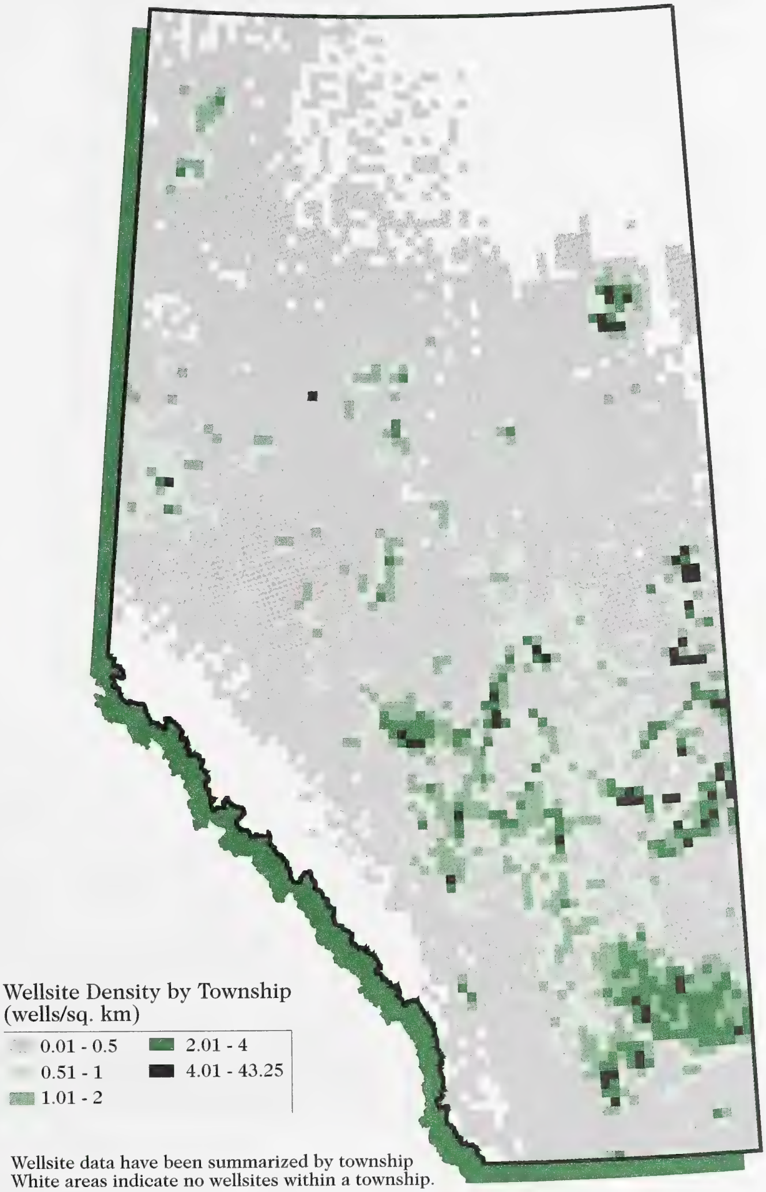
Oil and Gas Well Densities by Township

natural gas reserves, 60 percent of conventional oil reserves, 100 percent of bitumen reserves (bitumen is a mixture of oil, water and fine sand), and 70 percent of coal reserves. Sales of Alberta hydrocarbons totalled almost $17 billion in 1996, and contributed about 24 percent to the provincial GDP.

Most of these energy resources are exported. In 1996, 77 percent of natural gas and 75 percent of conventional oil produced went to other provinces and the United States (Alberta Energy and Utilities Board 1997a). The ***upstream oil and gas industry*** directly employed approximately 68 900 people in 1996. Indirectly, the industry employed an additional 27 600 people.

There are two basic types of oil in Alberta — conventional and non-conventional. Conventional oil includes light, medium and heavy crudes. All three are liquid petroleum that can flow from a well or through a pipeline without help or dilution. However, some medium and heavy crudes need an additive to flow through a pipeline.

Non-conventional oil includes bitumen extracted from oil sands,



Wellsite data have been summarized by township
White areas indicate no wellsites within a township.

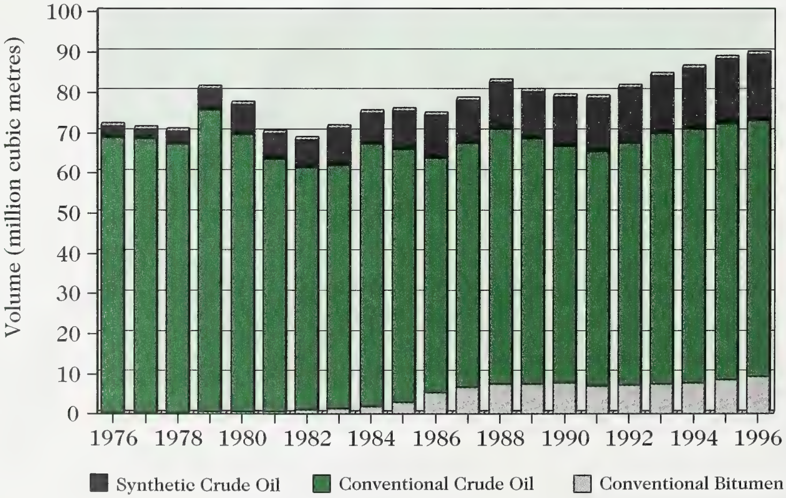
and light synthetic crude oil which is produced by "upgrading," or refining, the bitumen. Bitumen is too thick to flow at normal temperatures and must be heated and/or diluted before it can flow from a well. Currently, most bitumen produced in Alberta is extracted by surface mining techniques.

Conventional Oil

With current oil production slightly exceeding new additions to known reserves, Alberta's remaining established conventional oil reserves totalled 342 million cubic metres at the end of 1996 (Alberta Energy and Utilities Board 1997b). Alberta's conventional oil production peaked in 1973 at 83 million cubic metres. Since then it has dropped slowly, although not steadily, to approximately 55 million cubic metres in 1996, excluding pentanes plus and condensate (Alberta Energy and Utilities Board 1997a). Production continues to outpace additions to reserves and it might appear that Alberta could run out of conventional oil in a few decades. Every year, however, exploratory and development drilling and improvements to oil recovery techniques, add more oil to the known reserves, which extends the time that conventional oil reserves will last. In addition, oil sands production continues to assume greater importance as production of conventional oil decreases (Figure 3.27).

Figure 3.27

Total Annual Oil Production in Alberta, 1976 to 1996



Note: Conventional oil includes "pentanes plus" and condensate
Source: Alberta Energy and Utilities Board - Oil and Gas Annual Statistics, 1996

Figure 3.28

Location of Conventional Oil Deposits in Alberta

The major light and medium crude oil producing fields are Pembina near Drayton Valley, Swan Hills-Judy Creek, Rainbow Lake-Zama, Redwater, Provost, Red Earth-Utikuma and Leduc-Woodbend. Major heavy crude oil producing fields are Lloydminster-Wainwright, Provost-Hayter, and Taber-Suffield-Medicine Hat.

Figure 3.29

Location of Bitumen Deposits in Alberta

Oil Sands

Bitumen-soaked sand is located in three major deposits in Alberta - the Athabasca (the largest), the Cold Lake and the Peace River deposits. The oil-bearing sands in these deposits are located at various depths, from surface outcroppings to several hundred metres below the ground. Reserves at or near the surface are recovered using large-scale surface mining techniques (such as the Athabasca deposit near Fort McMurray). Deeper reserves are recovered using in situ extraction methods (such as near Cold Lake). In situ methods usually involve injecting steam down into the oil-bearing sands. The steam heats the bitumen, allowing it to be pumped out of the ground.

In 1996, the known bitumen reserves for both surface and in situ extraction totalled 661 million cubic metres (Alberta Energy and Utilities Board 1997b). Total deposits of bitumen in place in the province are estimated to be 270 to 400 billion cubic metres (1.7 to 2.5 trillion barrels), of which it is estimated that approximately 50 billion cubic metres (315 billion barrels) could ultimately be developed. Combined, these deposits underlie an area of 77 000 square kilometres in northeast and northcentral Alberta - more than 11 percent of the total provincial area. Indeed, Alberta's oil sands represent substantial wealth - but getting the resource out of the ground has always been a challenge.

The 1996 production estimates of bitumen and light synthetic crude from oil sands deposits totalled almost 26 million cubic metres — an average of 71 200 cubic metres per day (Alberta Energy and Utilities Board 1997a). The bitumen and synthetic oil portion of Alberta's oil production has grown at a relatively steady rate since the mid-1970s (Figure 3.27). This trend is expected to continue for the near future. Oil from oil sands now accounts for almost 30 percent of Alberta's total oil production.

Natural Gas

Natural gas deposits underlie a large portion of Alberta — roughly 40 percent of the total province. Areas with major gas producing fields and more intensive activity are located near Drayton Valley, Fox Creek, Medicine Hat-Suffield, Turner Valley-Jumping Pound, Waterton and Caroline (Figure 3.30).

Figure 3.30

Location of Major Gas Deposits in Alberta

As of 1996, Alberta's known natural gas reserves were estimated to be 1378 billion cubic metres (Alberta Energy and Utilities Board 1997b). However, Alberta's total natural gas reserves may be as high as 5600 billion cubic metres (an estimate based on technological advances in exploration and development, and suitable economic conditions) (Alberta Energy Resources Conservation Board 1992).

There are two basic types of natural gas in Alberta — sweet gas and sour gas. The term "sour" is applied to gas containing a high concentration of hydrogen sulphide (H2S). Natural gas containing little or no H2S is termed "sweet." Sour gas is typically found in deep, hot, high-pressure natural gas deposits such as those in the foothills and eastern slopes of the Rocky Mountains in Alberta. About one-third of Alberta's gas production contains hydrogen sulphide, and the province accounts for nearly 90 percent of Canada's total sour gas production. The majority of the sulphur content is removed in processing. It is then stockpiled as elemental sulphur, which is sold principally for producing fertilizers.

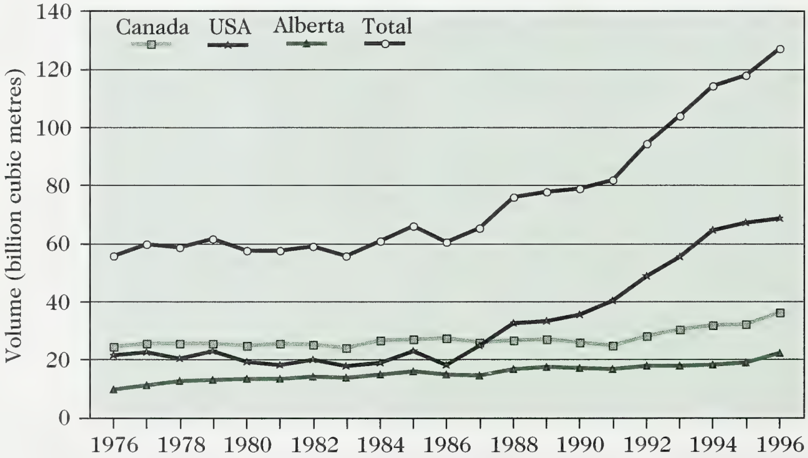
In 1996, the total marketable natural gas produced in Alberta was 127.2 billion cubic metres (Figure 3.31). In a twenty year period between 1976 and 1995, the number of producing gas wells increased from 9000 to 45 000 — a 500 percent increase. At the end of 1996, there were 467 sweet gas plants and 273 sour gas plants (52 with sulphur recovery equipment) operating in Alberta

(Alberta Energy and Utilities Board 1997a). Currently, approximately 23 percent of the natural gas produced is used to meet domestic demands for heating, electricity generation and petrochemical ***feedstock***. Approximately 77 percent of Alberta's natural gas production is exported from the province to the United States and to other parts of Canada (mainly Ontario).

In 1976, sales to the United States accounted for some 45 percent of all natural gas exported from the province. By 1995, this figure had increased to 68 percent. Although natural gas production and reserve additions have remained fairly constant in the U.S., the demand there is increasing. This means that the U.S. will have to rely more and more on gas imported from other places, such as Alberta. What does this mean for Albertans? The likely scenario is that the energy sector will continue its current elevated level of exploratory and development drilling for years to come, maintaining high rates of production to meet the demands of an expanding market.

Figure 3.31

Total Annual Production and Destinations of Marketable Natural Gas in Alberta, 1976 to 1996



Source: Alberta Energy and Utilities Board
- Alberta Oil and Gas Industry Annual Statistics

Coal

Coal consists of a complex range of materials, and coal from one deposit can differ greatly from that of another. The types of coal are generally classified, or ranked, by their overall carbon content. Anthracite has the highest carbon content, followed by bituminous, sub-bituminous and lignite coal (the lowest). Three types of coals are produced in Alberta — sub-bituminous, bituminous metallurgical, and bituminous thermal coal.

Figure 3.32

Location of Major Coal Deposits and Major Coal Mines in Alberta

Sub-bituminous coal is by far the most plentiful type in the province, and is found mostly in the plains east of the mountains. It's heating value is lower than the other types but is sufficient for use in electricity generating stations.

Bituminous metallurgical coal has a higher heating value making it suitable for making ***coke***, used in the iron and steel manufacturing industries. It is mined in the mountain region and exported from the province.

Bituminous thermal coal also has a high heating value. Most of the production of this type of coal is from the foothills and is exported to markets outside of Alberta. Regardless of their rank, Alberta coals are low in sulphur — ranging from 0.2 to 0.7 percent.

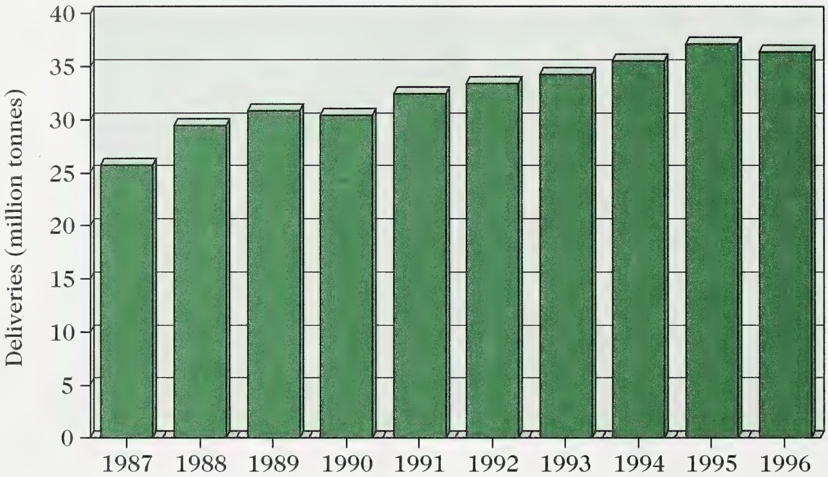
Alberta is the largest producer of coal in Canada, and the site of 70 percent of the country's coal reserves. Alberta's potential for coal development is enormous because much of the province is underlain by coal deposits. Our total coal resources are estimated at 2600 billion tonnes, and contain nearly twice the energy of all other non-renewable energy resources in Alberta, including oil, natural gas and oilsands. Estimates suggest that approximately 800 billion tonnes of the coal reserves are recoverable (790 billion tonnes of sub-bituminous coal and 10 billion tonnes of bituminous metallurgical and thermal coal).

There are 12 major active coal-mining operations in the province. Seven of these are located in the parkland and grassland natural regions, and five are located in the foothills and mountains of west central Alberta. Eleven are surface mines and one, Smoky River Coal near Grande Cache, is a combination surface and underground mine.

These 12 mines produced a total of 36.3 million tonnes of marketable coal in 1996 (Figure 3.33), with an approximate value of $600 million (Alberta Energy and Utilities Board 1997c). Almost 70 percent was used to generate electricity in the province. Alberta coal is also used as a feedstock in the production of primary iron and steel, and is an important source of energy for industrial processes such as cement manufacturing. Export markets for Alberta coal include Ontario, British Columbia, Japan, South Korea, Brazil and western Europe. Alberta's coal industry employed more than 2500 people at mine sites in 1996.

Figure 3.33

Total Annual Production of Marketable Coal in Alberta, 1987 to 1996



Source: Alberta Energy and Utilities Board - Alberta Coal Industry Annual Statistics 1996

Most Alberta coal is produced by surface mining methods, either strip mining or open pit. Strip mining is used on the plains. Large equipment, such as drag lines, remove the overlying soil and rock (overburden) to expose a relatively horizontal coal seam. Overburden is placed in piles behind the area being mined. When extraction is complete, the overburden is replaced and the land returned as much as possible to its former productive state.

Open pit mining is used most often in mountainous areas, where coal seams are irregular and localized. Blasting is often done to loosen the rock overburden, which is removed and initially stored outside of the pits. Mining is almost a vertical operation with pits becoming wider and deeper as the mining progresses. Reclaiming the site of an open pit mine in mountainous terrain is more difficult than reclaiming a strip mine on the plains.

Mines proposed to open in the near future (as early as 1998) will increase provincial coal production by 12.6 million tonnes annually. These new mines would be located on the plains at Brooks and near Tofield, and in the mountains at Cheviot, McLeod River, and Mercoal, which are southwest of Hinton.

Mineral Aggregate

Mineral aggregate includes sand, gravel, rock, and similar materials used in the construction industry for such things as buildings, roadways, bridges, airports and dams. It is essential for developing and maintaining Alberta's transportation infrastructure, and for the provincial construction industry.

Sand and gravel deposits are the primary source of mineral aggregate in Alberta. The mineral aggregate industry in Alberta is comprised of several thousand pits run by some 300 public and private sector producers (Edwards 1995). Total provincial production of sand and gravel in 1996 was estimated at 31.7 million tonnes, worth approximately $114 million (Giancola 1997). Alberta is ranked second in Canada for total sand and gravel production.

Mineral aggregate deposits in Alberta

In geological terms, there are several different types of mineral aggregate deposits in Alberta. The most common are *glaciofluvial, alluvial* and *eolian* deposits; the least common are *preglacial*.

Glaciofluvial deposits were formed by sand and gravel deposited by water flowing from melting glaciers. These deposits form the largest potential source of aggregate in Alberta.

Alluvial deposits were formed by rivers depositing sand and gravel after the last glaciation. Alluvial deposits are found within a river or stream, or on river valley terraces. They are numerous and widespread in Alberta.

Wind-carried sand is responsible for eolian deposits, which occur as thin sheets or dunes. These deposits are often covered by pine forest.

Preglacial deposits were formed by rivers depositing sand and gravel before the last continental glaciation. These deposits are rare in Alberta, but the gravel aggregate they contain is high quality. The most significant of these deposits can be found at Cypress Hills, Hand Hills, Swan Hills, Pelican Mountains, Obed Mountain, and near Edmonton, Calgary, Wetaskiwin, and Villeneuve. Because of their exceptional quality, preglacial deposits are ideal for large operations and for supplying major markets (Edwards 1995).

3.3.2 Agents of Change

Because this section deals with non-renewable resources, the discussion will focus less on the resource itself, as in previous sections, and more on the terrestrial ecosystems affected by a resource's development. A number of different environmental indicators are used explain what extensive exploration and development activities in the province can mean for terrestrial ecosystems. Actions and initiatives undertaken to reduce the effects of these activities are detailed in Section 3.3.3.

Seismic Exploration

Companies in the petroleum industry use seismic technology to locate oil and natural gas deposits. Seismic exploration involves mapping the sub-surface geology using sound waves generated from special equipment. This equipment, usually mounted on trucks, is carried across the landscape along straight lines and readings are taken at measured intervals. Often a series of parallel lines of measurement are needed to locate a petroleum deposit. In forested areas, vegetation is cleared to allow seismic exploration, leaving long, narrow cutlines, called seismic lines. These lines are often maintained for many years for further seismic exploration or general access by other forest users, but eventually they are reclaimed or naturally reforested.

Every year, a great deal of seismic activity occurs throughout Alberta, in both the White and Green Areas (refer back to Figure 3.1). The amount of seismic activity varies greatly from year to year, depending on the energy market and other factors. During the first five years of this decade, 341 288 kilometres were covered by seismic exploration (Table 3.3). Just over two-thirds (67.2 percent) of this activity occurred in the settled part of the province.

Table 3.3

Distance (kilometres) covered by seismic exploration, 1990 - 1994

	White Area	Green Area	Provincial Total
1990	33 528	23 683	57 211
1991	28 024	11 844	39 868
1992	37 121	16 160	53 281
1993	58 795	30 964	89 759
1994	71 877	29 292	101 169
Total	229 345	111 943	341 288

Source: Alberta Environment

Exploration companies often take advantage of existing cutlines for their seismic activity. During the 1990-94 period, about 45 percent of the exploration in the Green Area used existing cutlines (Table 3.4). Although this reduces the number of new seismic lines that must be cut, it delays the eventual reforestation of existing lines as they continue to be used.

Cutlines represent a small but immediate loss of habitat for species that inhabit forest ecosystems. By removing vegetation, cutlines can also increase the risk of local soil erosion on steep slopes and stream banks. Less obvious, however, are the long-term effects of the improved access cutlines give the general public to areas that were previously much less accessible. Hunters, anglers and off-highway vehicles can further disturb ecosystems and place more pressure on fish and wildlife resources when access is available. This type of improved access may be particularly important in environmentally sensitive areas, regions inhabited by rare plants or vulnerable wildlife, and areas used by local fur trappers and other traditional users.

Table 3.4

Distance (kilometres) covered on new and existing seismic lines in the Green Area, 1990 - 1994

	Total distance covered by seismic exploration in the Green Area	Exploration using existing seismic lines	Exploration using newly cut seismic lines	Percentage on existing cut lines (%)
1990	23 683	10 639	13 044	45
1991	11 844	5825	6020	49
1992	16 160	7390	8769	46
1993	30 964	13 591	17 373	44
1994	29 292	12 340	16 952	42

Source: Alberta Environment

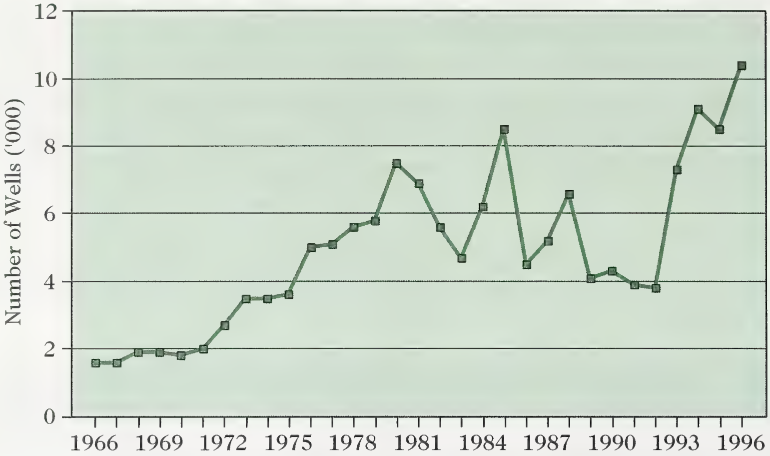
Well Sites and Access Roads

Since 1993, there has been a sharp increase in the number of wells drilled in the province each year (Figure 3.34). The total number of wells completed in the province during 1996 was 10 396 (Alberta Energy and Utilities Board 1997a). This includes exploration and development of conventional oil and natural gas, oil sands drilling activity, and dry wells. This was a record high total, bringing the number of wells drilled in the province to 176 500 since 1951. These well sites vary in size, with an average of about 1.4 hectares. Using directional drilling, several wells may be drilled from one site, reducing the area disturbed.

Of all the wells drilled in the province, many have been abandoned and the sites reclaimed. The Alberta Energy and Utilities Board estimates that there are currently 10 000 wells that have been inactive for ten or more consecutive years. Section 3.3.3 discusses a new program to reduce the number of long-term inactive wells through decommissioning and reclamation.

Figure 3.34

Total Number of Oil and Gas Wells Drilled Annually in Alberta, 1966 to 1996



Note: Total also includes unsuccessful, service and suspended wells
Source: Alberta Energy and Utilities Board
- Alberta Oil and Gas Annual Statistics 1996

Areas with the most wells and drilling activity generally match the areas with large oil and gas reserves, and the conditions that promote the resource's most economical recovery. Some areas of the province have experienced an especially high degree of activity from the oil and gas industry:

Grassland - Medicine Hat-Taber and north to Drumheller

Parkland - the majority of the parkland

Foothills - a large portion between Sundre and Edson; Swan Hills, Beaverlodge-Spirit River

Boreal Forest - Rainbow Lake, Cold Lake-Bonnyville; Red Earth; Hay-Zama Lakes; Fort McMurray

The potential effects of well sites and other production facilities on both terrestrial and aquatic ecosystems tend to be local. Problems can include petroleum spills, well casing failures and blowouts, and air, water and noise pollution. Industry and regulatory agencies are usually able to contain these problems before they become widespread and cause significant environmental damage. The Alberta government requires companies to have emergency plans in place to deal with petroleum spills or well casing failures.

Industry must follow guidelines and directives from the Energy and Utilities Board and Alberta Environment for construction, maintenance and pollution control. Alberta Sustainable Resource Development, the public land manager, also sets industry operating conditions to lessen the possible effects of well site and access road construction and use.

In additon to the land occupied by the well sites, extensive networks of pipelines and access roads link oil and gas wells to one another and to processing facilities. Sometimes these networks can be minimized when closely grouped wells share access routes.

Access roads are built by the companies and are used for as many years as required before being reclaimed. During their existence, these roads are a significant linear disturbance of the landscape. This is particularly true in forested ecosystems where previously what may have been a continuous cover of trees becomes fragmented by a combination of well sites and linear corridors.

Overall, access roads probably have a greater influence on ecosystems than seismic lines. Access roads tend to be used by larger vehicles for a longer period of time, and their reclamation and revegetation is often delayed for many years. Some effects on terrestrial and aquatic ecosystems, especially in areas with many access roads, include the following: soil erosion, siltation in streams, increased dust and noise, wildlife-vehicle collisions, increased "edge effect" and habitat fragmentation, habitat avoidance near busier roadways, and increased access for the general public. However, there are a number of initiatives and industry guidelines in place to minimize disturbance and reduce overall effects (see Section 3.3.3).

Pipelines

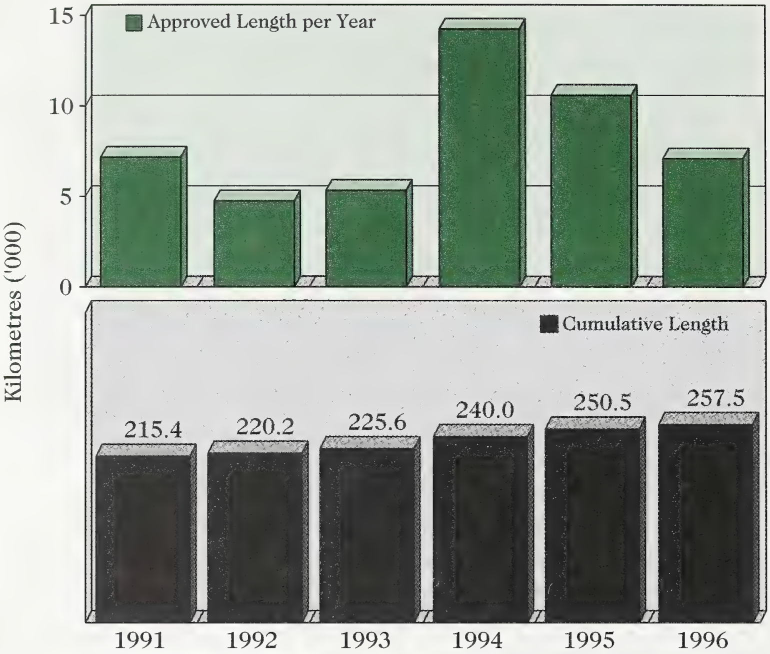
Pipelines administered by the Energy and Utilities Board in Alberta totalled 257 450 kilometres at the end of 1996 (some small portion not attributed to the oil and gas sector), but this number does not include the length of pipelines administered by the National Energy Board (see Figure 3.35). With the width of a pipeline right-of-way averaging 15 metres, the total area affected was approximately 3860 square kilometres. Reclamation standards for pipeline corridors are generally sufficient to mitigate most environmental effects. However, pipeline rights-of-way often involve clearing of native vegetation, thereby contributing to habitat fragmentation.

The energy sector follows special guidelines to help conserve remaining areas of native prairie in the province. Disturbances from pipeline construction in native prairie areas are minimized by a number of procedures: use of equipment and trenching methods that cause the least disturbance; pipeline routes that follow already-disturbed areas (such as existing lines or access roads); and efforts to preserve native sod and prevent soil erosion (Alberta Energy and Utilities Board 1996a).

Pipeline failure from internal or external corrosion continues to be a source of concern for the industry. Pipeline failure accounted for 40 percent of all categories of spills in the petroleum industry in 1996 (Alberta Energy and Utilities Board 1996b). Under the direction of the Energy and Utilities Board, Alberta's energy industry is currently evaluating the extent of stress corrosion cracking in Alberta pipelines and taking appropriate measures.

Figure 3.35

Length of Pipelines under Alberta Energy and Utilities Board Jurisdiction



Source: Alberta Energy and Utilities Board

Focus Issue — Linear Disturbances

Man-made corridors (such as roads, seismic lines and other rights-of-way) are linear disturbances that are largely different from their natural surroundings.

Linear disturbances may affect terrestrial ecosystems, particularly wildlife communities, in a wide variety of ways. Habitat loss is one effect that tends to be small over a large landscape. Another effect, although less obvious, is habitat fragmentation. For forest-dwelling wildlife living in landscapes divided by linear disturbances, the degree of habitat fragmentation is directly related to the amount of linear disturbance (Jalkotzy *et al.* 1997).

Linear disturbances are also subject to "edge effects." This phenomenon has been observed by ecologists where two different plant communities or successional stages meet. Both habitats contribute plant and animal species to the edge zone, their combined effect making the edge more valuable to wildlife than either habitat alone.

Linear corridors create more edge which benefits some species but not others. For example, the brown-headed cowbird is an "edge" species that prefers to feed in open areas and lay its eggs in the forest, away from the edge. However, it is also a nest parasite, laying its eggs in the nests of other forest birds. American studies have shown that in recent decades, brown-headed cowbird populations have increased dramatically, and have been implicated in the decline of other forest-dwelling birds (Robinson *et al.* 1993).

Roads probably have the greatest impact on wildlife of all man-made linear disturbances. The most important effects are direct mortality (from wildlife-vehicle collisions), indirect mortality (from increased human activity), and reduced habitat effectiveness from avoidance in the vicinity of busy roads (Jalkotzy *et al.* 1997). The effects of pipeline, seismic lines, and power line rights-of-way are similar to those of roads. However, their impacts on wildlife are often less significant because these linear disturbances tend to be narrower, with fewer people and less associated vehicular traffic.

Wildlife species that are sensitive to human disturbance and that need large amounts of land (such as the grizzly bear) are more likely to be affected by linear distrubances than species that need smaller areas (such as the snowshoe hare). This is because species with home areas of several hundred square kilometres are more likely to encounter human development somewhere within that space (Jalkotzy *et al.* 1997).

Linear disturbances can also improve wildlife habitat, benefiting certain species at certain times. For example, some native species of grasses, forbs and shrubs can invade soils newly exposed by a linear disturbance. This vegetation in turn provides habitat for small rodents, as well as a good food supply for wildlife, such as deer and caribou. Large roaming animals, such as bears, wolves and deer, will often use the less busy roads and cutlines as travel routes. Birds of prey, such as ospreys and hawks, will often perch and nest on the poles of electricity transmission lines.

Surface Mining

Surface mining is the primary method used to extract to coal and bitumen reserves found in Alberta. Although not widespread, surface mining involves an intense, local alteration of the landscape, that removes large quantities of overburden (soil, glacial till, bedrock) to expose the hydrocarbon resource buried underneath. When mining operations are completed, they usually leave a series of open pits that must be reclaimed.

Despite the huge coal reserves in Alberta, there are currently only 12 major coal mines in operation comprising a total disturbed area of 10 100 hectares. Typical extraction technology in non-mountainous areas involves the use of massive draglines to remove the overburden and expose the coal seams. Power shovels and trucks are used to haul the coal to a nearby processing facility. Blasting with explosives is sometimes also required to loosen the bedrock before it can be removed to expose the coal. Some general environmental pressures include noise levels (machinery, blasting), air quality (coal dust), water quality and stream diversions, soil and vegetation removal. Reclamation of open pit coal mines tends to be more difficult in mountainous areas because of the naturally shallow soil depth and greater variations in topography.

Focus Issue — Reclaiming Coal Mines in the Mountains

Coal seams found along the eastern slopes of Alberta's Rocky Mountains produce a particular type of coal, bituminous metallurgical coal, used in manufacturing steel. Open pit mining methods are used to expose and extract the coal seams. This can involve diverting streams around the site, and removing trees, soil and overburden to retrieve coal that may be more than 200 metres underground. This significant alteration of the landscape and ecosystem makes reclamation of an open pit mine a special challenge.

There are several factors that limit the ability to reclaim an open pit site to previously undisturbed condition. The climatic conditions in mountainous areas (especially sub-alpine and alpine) are generally very limiting to some natural processes. Soil formation is typically slow, and the resultant thin soils tend to be rocky and of poor quality. In turn, the cooler temperatures, short growing season, drying winds and poor soils limit the speed and type of plant growth. Topography also plays a major role because steeper slopes generally increase the amount of runoff and soil erosion in exposed areas, further reducing the amount of soil and moisture available for plant growth.

The combined effect of these factors means that regrowth on reclaimed lands occurs slowly. Sometimes 60 years are needed for tree-dominated vegetation to become established. This time frame would be much longer if revegetation was left completely for natural processes (Cardinal River Coals 1996).

Contouring of the land, grading of overburden and soil, seeding with grass and legume mixtures, and extensive fertilization are designed to speed plant colonization and plant development on reclaimed mine sites. When a ground cover is well established, seedling trees can be planted in locations considered optimum for tree growth. Streams that were diverted are typically re-routed

through their natural valley, and habitat enhancement methods are used to provide quality fish habitat. Depleted mine pits may be filled with water and stocked with fish to provide a recreational fishing lake where none existed previously. These reclamation techniques have proven successful in helping to restore mined areas, hastening their colonization by native plants and animals and subsequent use by people.

At present, there are three oil sands mining operations in the province, with a combined disturbed area of 15 200 hectares. The two largest, Syncrude and Suncor, are located adjacent to the Athabasca River north of Fort McMurray. Massive bucketwheel excavators, conveyor belts, power shovels and trucks are used to remove the overburden and expose the oil-bearing sands for extraction and processing. An important difference from coal mining, however, is the by-products produced by separating bitumen from sand. The hot water separation process removes large volumes of sand and fine tailings — a mixture of processed water, silt, clay and a minor amount of residual bitumen.

Current technology pumps fine tailings into large settling ponds to allow the water to be clarified for reuse in the separation process. The fine tailings settle to the bottom of the ponds. However, these fine tailings still contain about 85 percent water. This water contains high levels of chlorides (salts), and soluble organic compounds (principally naphthenic acids). Because the settling ponds are filled continuously, the water retains high levels of these compounds and becomes acutely toxic to fish and other organisms. Ongoing research is currently developing alternatives for the management of fine tailings. A number of reclamation technologies are now available for the oil sands industry, and companies are beginning to use them (see Section 3.3.3).

The total area under lease for oil sands development is 20 930 square kilometres. These leases are located on both sides of the Athabasca River near Fort McMurray and, if developed in the future, would represent a significant land disturbance in the lower Athabasca River Basin.

Mineral Aggregate Extraction

Sand and gravel is mined throughout the province and, although numerous, operations tend to be small. The majority of sites are on private land. At the end of 1996, there were approximately 3560 sand and gravel pits in Alberta on private land. Combined, these pits represent a total disturbed area of 19 300 hectares. On public lands, there were 1561 sites (1997) with an associated disturbance estimated at 10 000 hectares.

Aggregate extraction can involve some degree of change to the environment, and can influence other land uses. Sand and gravel pits are often favourite recreation areas for off-highway vehicle enthusiasts. Important gravel deposits are often located in sensitive environmental areas (such as river valleys), where any type of mineral extraction usually affects both aquatic and terrestrial ecosystems. The effects can include downstream effects on water quality (most common), and habitat loss and disturbance (highest potential impact occurs in southern Alberta valleys where this habitat is both a critical and limited supply for some species). Many preglacial deposits in locations other than river valleys often require the removal of a significant amount of overburden. Other factors include a deposit's proximity to groundwater aquifers, or to areas considered ecologically sensitive or unique, because they preserve flora, fauna, historic and other unique natural features (for example, ecological reserves, natural areas, and provincial parks).

3.3.3 Actions

On a provincial scale, energy sector activity is one of the most important land use issues in Alberta. Exploration and development for oil and gas is widespread throughout the province. These activities commonly disturb the land surface and remove it from other uses, usually temporarily, but sometimes for lengthy periods. To some degree, development of our energy reserves affects most other uses of the land surface, particularly agriculture, forestry, outdoor recreation, heritage appreciation, fish and wildlife habitat, and so on. Recognizing the need to make this development more environmentally sound, the Alberta government and industry have developed a number of actions and initiatives that address environmental concerns, and reduce or mitigate their effects.

Environmental Impact Assessments

Applications to undertake major energy projects (such as coal mines, oil sands, and petrochemicals) usually require an Environmental Impact Assessment (EIA). An EIA must include enough detail to allow regulatory authorities to make informed decisions on whether or not a project should proceed. The EIA addresses the biophysical and social consequences of the development, and discusses the available and proposed options to mitigate these effects. An EIA also provides a comprehensive biophysical impact assessment (for example, effects on water, air, soils, vegetation, wildlife), a cumulative effects assessment, a socio-economic impact assessment, an environmental protection plan (including mitigation measures, environmental monitoring and research), a conceptual development and reclamation plan, and a solid waste management plan.

Guidelines to Minimize Impacts

The Canadian Association of Petroleum Producers (CAPP); Alberta Energy and Utilities Board (EUB); Alberta Environment (AENV); and Alberta Agriculture, Food and Rural Development (AFRD) provide necessary information and guidance to help the energy industry reduce its effects on the environment. Collectively, these agencies and associations issue information letters, interim directives, guidelines and criteria for conducting activities in an environmentally responsible manner. The following are examples of the services they provide:

- Basic Environmental Program - Contains a compilation of regulatory requirements and industry practices that define expectations for environmental performance in the petroleum producing industry (CAPP);
- General guidelines and criteria for decommissioning and reclaiming well sites, pipelines, access roads and associated facilities (CAPP, AENV, AFRD);
- General environmental protection guidelines for oil production sites, pipelines and pits (AENV, AFRD);
- Low-impact seismic guidelines (AENV, AFRD);
- Sulphur recovery guidelines for sour gas plants in Alberta (AENV, EUB);
- Sour gas flaring requirements and changes to regulations (EUB);
- Revised guidelines for minimizing disturbance on native prairie areas (EUB);
- Guidelines for oil and gas developments (EUB);
- Oilfield waste management requirements for the upstream petroleum industry (EUB);
- Noise control directive (EUB);
- Guidelines for well site and access road construction prior to the issuance of a well licence (EUB);
- Special requirements for the Hay-Zama Lake Complex (EUB);
- Operating guidelines for the industry activity in caribou ranges of northwest Alberta (EUB); and
- Procedures for sand and gravel operations on public lands (AENV, AFRD).

New Technologies Reduce Disturbance

Directional drilling in heavy oil and bitumen reserves has reduced considerably the number of wells needed in a given area. This also reduces the amount of land disturbed for well sites, as well as the amount of energy used to produce steam to heat the oil-bearing formations. Directional drilling gives industry access to reservoirs under lakes or other environmentally sensitive areas. By turning a full 90 degrees under ground, wells can bore horizontally into formations, greatly increasing productivity by exposing a larger area of

hydrocarbon bearing rock to the well bore. Some wells use multiple horizontal offshoots, which minimizes the number of wells needed in a given area. Directional drilling also allows companies to group several well heads at a single production site, further reducing the spread of single well sites in a development area.

Many exploration companies have adopted the use of low-impact seismic lines. Essentially, a low-impact seismic line is a narrow line (up to an average of 5 metres in width) cut in a way that minimizes disturbance to ground cover. Low-impact seismic combines hand cut lines and bulldozer cut lines. In areas where wildlife and timber resources are at risk, the line meanders to avoid marketable timber and provide line-of-sight blockage for wildlife. Thanks to miniaturization and improved hydraulics, some shothole drilling units (for placing explosives used in seismic testing) are less than two metres wide, reducing the width of the right-of-way needed. Exploration companies have also increased their use of helicopter-portable equipment in the search for hydrocarbon reserves in sensitive areas.

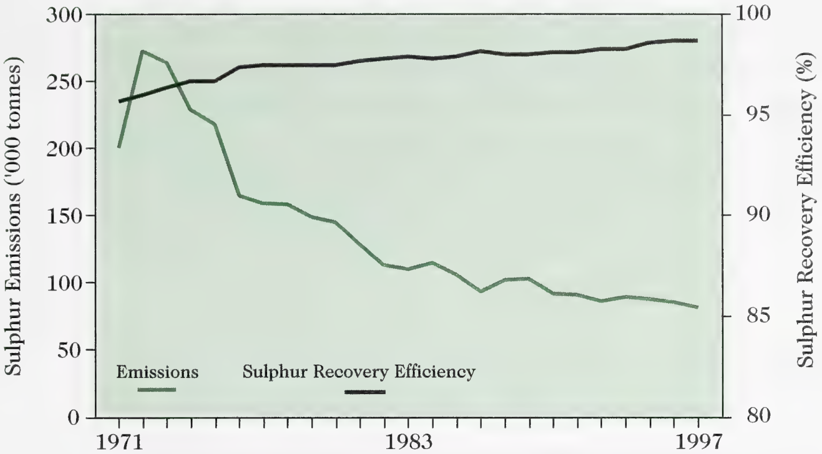
Pollution Control

Industrial emissions into the air can affect terrestrial ecosystems. For example, "greenhouse gases" contribute to global warming, acid deposition can increase soil acidity, and ground-level ozone can affect plant growth. There are several programs and initiatives in Alberta to address the issue of greenhouse gases (such as carbon dioxide) and other harmful emissions (such as sulphur dioxide) from oil and gas production. One such program, Solution Gas Conservation and Emissions Reduction, was adopted by the EUB and industry to conserve natural gas and reduce harmful emissions to the atmosphere. Under this program, petroleum companies in the Red Deer area reduced the amount of solution gas burned in flare stacks by one million cubic metres in 1996. It is estimated that carbon dioxide (CO_2) emissions were reduced by approximately 270,000 tonnes as a result of these actions. Between 1988 and 1996, reductions in solution gas flaring from oil production facilities across Alberta reduced the amount of CO_2 released into the atmosphere by more than 1.3 million tonnes (Alberta Energy and Utilities Board 1996b).

Because of improved sulphur recovery efficiency, total sulphur dioxide (SO_2) emissions from sour gas plants have decreased in recent years despite steadily increasing natural gas production (Figure 3.36). Strong enforcement actions are applied to companies that fail to pass inspections. Natural gas facilities that severely affect the public, or the environment, are suspended until improvements are completed to ensure the facility operates with minimal impact.

Figure 3.36

Efficiency and Emissions of Sulphur Recovery Plants in Alberta, 1971 to 1997



Source: Alberta Energy and Utilities Board

Companies involved in oil sands mining near Fort McMurray are also active participants in the Voluntary Challenge and Registry Program, an initiative to reduce greenhouse gas emissions. Between 1988 and 1995, Syncrude decreased CO_2 emissions by 21 percent per barrel of bitumen produced. Suncor has reduced its SO_2 emissions by approximately 75 percent through its recently installed Flue Gas Desulphurization unit.

To reduce the impact of potential spills from oil wells and pipelines, industry has established spill-containment equipment depots across Alberta. Companies conduct intensive training programs to ensure that employees are well prepared to act quickly and efficiently in the event of a spill. The industry has also developed new systems for handling and formulating drilling muds. Some examples are non-toxic muds that reduce the production of oily and salty wastes, while "closed loop systems" minimize fresh water requirements. Tanks or plastic-lined ponds contain the muds so that they do not penetrate into the ground water.

Land Reclamation

One of the most important stages in the development of modern resource extraction sites is the planning for and implementation of land conservation and reclamation. Conservation typically involves the separate removal and storage of topsoil, subsoil and overburden that covers the desired resource. Land reclamation is a process that returns developed and potentially degraded lands to a capability equivalent to their condition before disturbance. Reclaimed sites can be returned to former uses such as farmland, urban land use, recreation areas or other uses.

The role of Alberta Environment and Alberta Agriculture, Food and Rural Development is to administer conservation and reclamation guidelines, monitor reclamation efforts, and certify that reclamation is complete. The departments also support research into new conservation and reclamation technologies.

Table 3.4 summarizes the land area that non-renewable resource extraction activities have disturbed and reclaimed. Although reclamation is a significant challenge for oil sands companies, they are still experimenting to determine the best reclamation methods — as the table shows, none of the disturbed area listed has been certified as reclaimed.

Table 3.5

Provincial reclamation summary for December 31, 1996

Activity	Number of Sites	Area Disturbed (hectares)	Area Certified Reclaimed (hectares)
Coal Mine[1]	14	10 100	1720
Oil Sands	3	15 200	0
Sand and Gravel[2]	3560	19 300	1050[3]
Well Sites	162 000[4]	327 000[5]	148 000

[1] Includes two inactive mines.

[2] On private land only.

[3] Estimated area - 146 pits reclaimed.

[4] Total number of oil, gas and injection wells on lands under jurisdiction of the Province, 1938 to December 31, 1996.

[5] Based on an estimated average size of 2.02 hectares (includes road and well site).

(Source: Alberta Environment)

Orphan and Inactive Well Programs

An orphan well is an inactive well for which there is no owner or operator legally responsible for its prior abandonment. Under EUB regulations, abandonment means the well must be cemented and capped. Oil and gas companies established an Orphan Well Abandonment Fund in 1992 to care for and abandon the wells according to EUB regulations. To date, the fund has successfully abandoned 155 orphan wells (Alberta Energy and Utilities Board 1996c). The scopes of the fund will be expanded to include the reclamation of well sites and other upstream facilities.

A long term inactive well is defined as one in which operations such as production and injection have not taken place for 10 or more consecutive years. The EUB estimates that there are approximately 10 000 long-term inactive wells in Alberta. These wells are of particular concern because they pose a significant financial risk to the abandonment fund. In an effort to reduce the number of inactive wells, a special Long Term Inactive Well Program was created based on recommendations from a joint government/industry committee.

Petroleum Tank Management Association of Alberta

One problem associated with the marketing and use of petroleum products is leakage from underground storage tank systems. Studies show that up to 35 percent of underground storage tanks installed during the seventies, eighties, or earlier, will leak before their removal. There are a number of reasons underground tanks leak but the most common causes are improper installations and corrosion of steel tanks or lines. Sites also become contaminated by the overfilling of storage tanks.

Petroleum leakage from underground storage tanks can have adverse effects on human health and the environment. Prolonged exposure to vapours originating from leaked fuels can result in increased cancer or other health risks. There are a number of options available to manage these risks but implementation costs can be quite high.

A provincial government program created a database of existing storage tanks in the province and worked with industry and regulators to formulate recommendations for changes to Alberta Fire Code tank regulations. The Petroleum Tank Management Association of Alberta was established in 1994 to promote the safe management of petroleum storage tank systems and sites in Alberta. It maintains the registry of storage tanks and certifies qualified people to install, alter, or remove storage tank systems.

11th International Conference on Coal Research

This triennial conference is recognized as the world's premier source of authoritative information on coal research. Alberta hosted the conference in September 1997. Its focus was clean coal technology and scientific advances to ensure the environmental acceptability of coal. The conference also reported on the industry's progress in addressing issues related to greenhouse gas emissions and global climate change.

This type of meeting provides Alberta's coal industry with the latest information on current and planned research, and development programs.

3.3.4 Future Directions

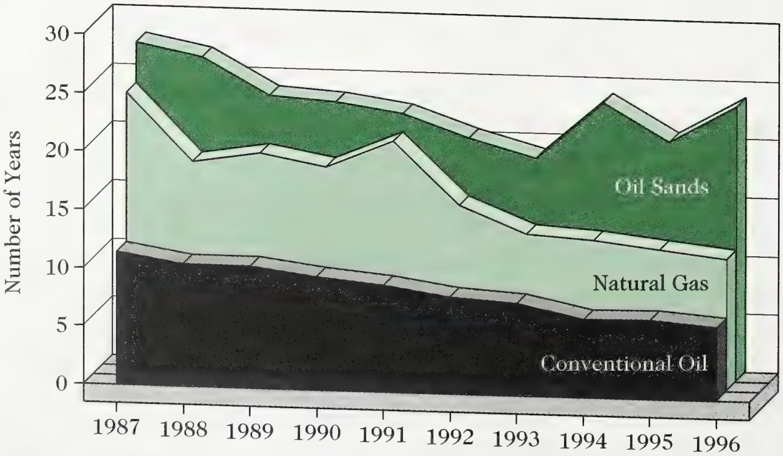
Future Expansion of Oil Sands Mining

As Alberta's conventional oil deposits are slowly depleted (Figure 3.37), bitumen reserves will assume a more important role in the province's energy future. A National Task Force on Oil Sands Strategies 1995 report predicted that oil sands production would triple to 190 800 cubic metres/day (1.2 million barrels/day) over the next 20 to 25 years. For this to occur, it is likely that several more oil companies will have to develop their existing leases. Approximately 21 000 square kilometres of the Boreal Forest natural region near Fort McMurray are now under lease to various energy companies for extracting bitumen reserves by surface mining methods. Over the next 25 years, existing plans to expand current operations and to build new projects can be expected to affect parts of an area totalling between 1200 and 1400 square kilometres.

Alberta oil sands deposits contain two-thirds of the world's bitumen, which makes them one of the largest hydrocarbon accumulations in the world. The National Oil Sands Task Force stated, "the oil sands resource is so massive that Canada could rely on it for the next 100 years to maintain its competitive position as self-sufficient in petroleum production and a net exporter of energy" (National Oil Sands Task Force 1995). The majority of these reserves, too deep for surface mining operations, contain an estimated 270-400 billion cubic metres (1.7-2.5 trillion barrels) of bitumen. Given the size of the reserves, and if synthetic crude oil and bitumen products remain viable as sources of petroleum products, it is easy to conceive that development in the area will expand considerably over the next few decades.

Figure 3.37

Remaining Established Reserves of Oil and Gas in Alberta, 1987 to 1996



Source: Alberta Energy and Utilities Board 1997

New Recovery Technology for Oil Sands

In 1987, the Alberta government and nine industry partners established a special Underground Test Facility, located near Fort McMurray. (The Government has since sold its interest in this project.) This test facility is an experimental bitumen production operation to test Steam Assisted Gravity Drainage (SAGD) - an in situ recovery method using steam. This new made-in-Alberta technology promises to greatly increase the production of the province's oil sands and heavy oil deposits. Industry now has a proven method to unlock the tantalizing wealth that is buried too deep for open pit mining.

The concept of SAGD is relatively simple. A pair of closely spaced horizontal wells is drilled into an oil sands reservoir. Steam is then injected into the upper well, heating the surrounding bitumen and causing it to flow by gravity down to the lower producing well, from which it is lifted to the surface. Unlike surface mining, SAGD requires neither major plants nor large work forces, allowing such projects to be undertaken in remote areas. SAGD promises to tap deeper oil sands reservoirs than surface mining methods, with less manpower, expense and environmental impact.

Many companies are experimenting with this new technology in both bitumen and heavy oil deposits. Overall production of bitumen and heavy oil expected to triple over the next 20 years. A major part of that growth will be based on SAGD technology (Corbett 1997).

Future Development of Mineral Resources

The Canada/Alberta Partnership Agreement on Mineral Development was a $10 million jointly funded initiative with a four year duration, ending in 1996. The primary objective of the agreement was to diversify Alberta's economic base by developing and enhancing the non-petroleum mineral industry in the province. Much of Alberta's metallic and industrial mineral potential had not been identified previously, and very little information was available to the public. Without such information, the minerals industry had little incentive to increase exploration efforts.

The Mineral Development initiative was intended to address this information deficiency and encourage greater mineral resource development in Alberta. Several geological studies identified and analyzed the market potential for metallic and industrial minerals, particularly in the exposed Precambrian shield of northeastern Alberta (Langenberg and Eccles 1996, Langenberg *et al.* 1993). The data the initiative supplied could act as a catalyst for future mineral development in that area of the province.

Recent exploration (winter 1996-97) in the Buffalo Head Hills area northeast of Peace River has discovered diamonds. Ashton Mining of Canada Inc. has tested

samples for macro- and micro-diamonds with promising results. Further exploration and testing will be conducted to determine if the formations in this area have potential for commercial diamond production.

Future mineral development in the province may also come from aggregate deposits and oil sands deposits. Some existing sand and gravel operations are currently mining for other co-products such as gold, which they generally produce in small quantities. Further efforts may discover larger amounts of gold in some deposits. The Athabasca Oil Sands are known to contain significant quantities of heavy metals such as titanium and zirconium. Titanium and zirconium minerals are concentrated in the tailings from bitumen extraction. Analyses show that these tailings are the world's second richest titanium resource. In 1994, the total production of these minerals from both Syncrude and Suncor equalled 293 250 tonnes per year of titanium dioxide, and 86 700 tonnes per year of zirconium dioxide (Alberta Chamber of Resources, no date).

Coal Production Increase?

Coal is the most abundant fossil fuel in the world, and is by far the international fuel of choice for generating electricity. Economic development and population growth in developing countries will likely increase the demand for this resource. Alberta has a competitive advantage over many other coal-producing nations (for example, England and Germany) whose reserves are in mature stages of development. Alberta's coal resources are widely distributed, have low production costs, and have diverse characteristics that can compete in a number of domestic and international markets.

Mineral Aggregate Depletion

The demand for mineral aggregate will continue to rise as economic development spawns new construction and the existing infrastructure requires ongoing maintenance. This demand will affect the environment, not only from the related land disturbance, but also because of increased hauling distances and associated impacts (such as vehicle emissions).

Reserves of sand and gravel are being consumed at twice the rate at which they are being discovered (Edwards 1995). In one-half of all municipalities in Alberta, aggregate producers estimate that their sand and gravel reserves will be depleted in about 20 years without further discoveries. It is predicted that, as sand and gravel supplies are depleted, bedrock will become the future source of mineral aggregate for Alberta (Edwards 1995). Exposed bedrock formations are naturally occurring in the foothills, mountains, and the Canadian Shield area of northeastern Alberta.

The development of a long-term strategy to recognise and properly manage this vital, finite resource is essential. The strategy should address such issues as detection and protection of the resource, and how to maximize resource use while minimizing environmental impacts.

3.4 Urban Areas, Transportation, and Utility Corridors

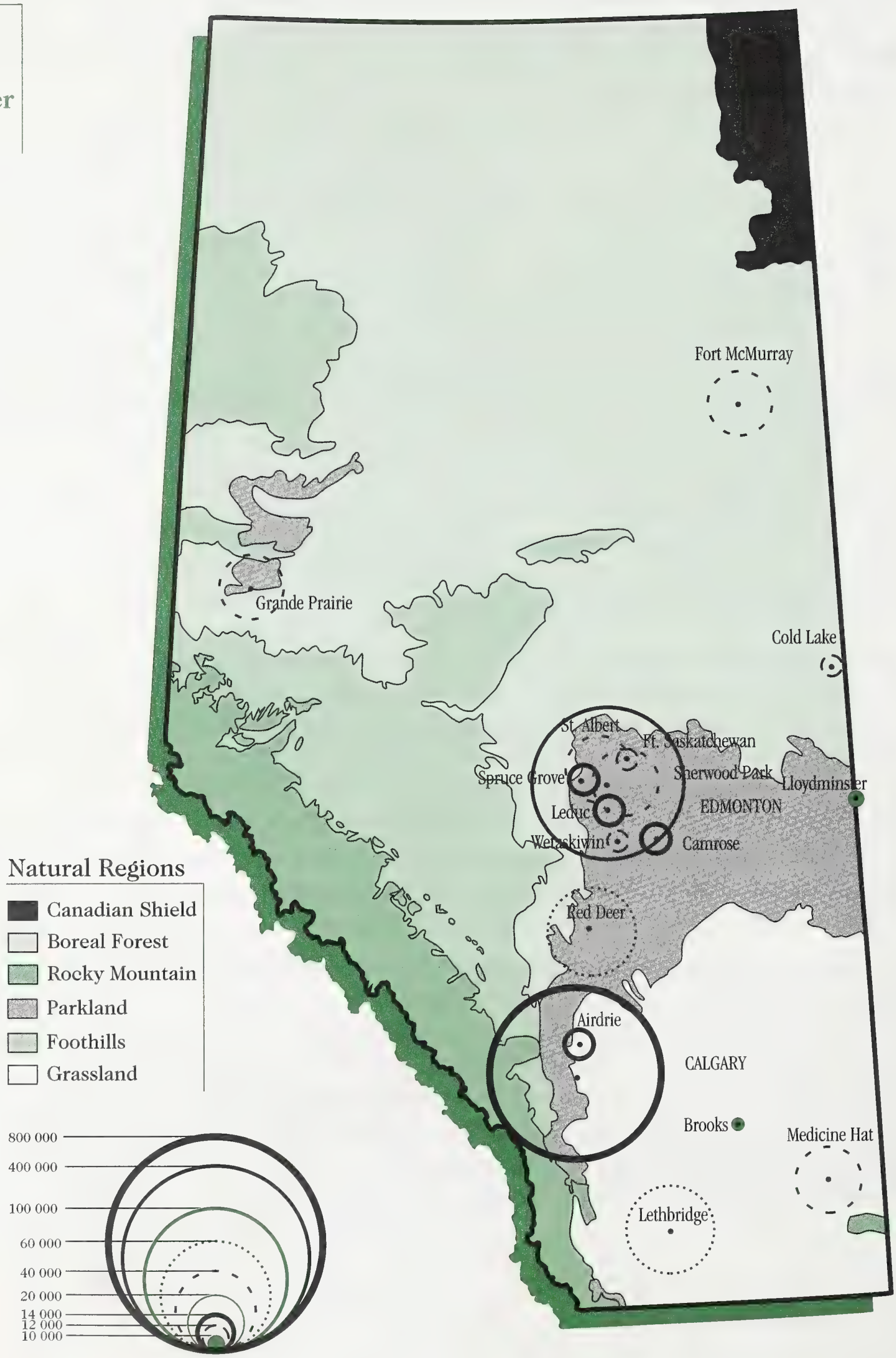
Many early settlements were established along Alberta's river valleys. Here there were appropriate conditions of climate and soil, and a continuous supply of fresh water. The larger rivers were capable of providing an abundance of water for growing industrial, commercial and residential use, and for waste assimilation. Where the water supply was adequate, and the proper socio-economic conditions existed, a town eventually became a city. This scenario has occurred on several of the larger rivers in the province — the North Saskatchewan, South Saskatchewan, Red Deer, Bow, Oldman and the Athabasca.

The urban form that developed expresses itself in a wide range of landscape alterations, anything from sterile concrete, pavement and skyscrapers, to natural-looking parklands. Urbanization involves the growth of urban centres and the expansion of urban influence into rural areas as the urban population increases. For example, rural farmlands that existed for decades adjacent to Alberta's major cities are now under constant pressure from urbanization. Urbanization typically involves intensive landscape changes that alter most natural ecosystems and values, as well as the potential for the extended use of renewable resources (Warren *et al.* 1989).

The transportation system in Alberta moves goods and people on a network of roads and rail lines connecting urban and industrial centres. Our success and growth as a trading province continues to rely heavily on this network. Transportation routes provide all economic sectors with access to resources, facilities, markets and labour. They also provide basic access to employment and consumer goods, and are key to a wide variety of social, education and leisure activities. Albertans consider themselves fortunate to have use of an extensive, well-maintained transportation network.

Figure 3.38

Alberta Urban Centres with Population Over 10 000



3.4.1 Present Conditions

Population and Urban Areas

The total human population in Alberta is approximately 2 744 700 people, based primarily on 1996 census results. More than 1.8 million people (about two-thirds of the population) live in Alberta's 17 cities (Figure 3.38), ranging in size from smaller centres such as Spruce Grove and Wetaskiwin, to the major cities like Edmonton and Calgary (Alberta Municipal Affairs 1997). In 1996, the five largest centres — Edmonton, Calgary, Red Deer, Lethbridge and Medicine Hat — were home to almost 1.6 million (86 percent) of the province's city dwellers.

The total land base occupied by urban centres in Alberta is relatively small when compared with the area of the province. The cities of Edmonton, Calgary, Red Deer, Lethbridge and Medicine Hat comprised a total area of 172 900 hectares in 1996. This figure represents less than 0.3 percent of the provincial land area. Nonetheless, the influence of large-scale urbanization often extends beyond the boundaries of the cities themselves.

Roads and Rail Lines

Two major modes of transport used to move goods and people in Alberta are road and rail. The majority of Alberta's land-based transportation network is represented by roads. Alberta currently has more than 178 000 kilometres of roads (Table 3.6) and about 18 000 kilometres of single-lane trails. The majority of roadways are in the form of smaller local, or municipal, roads that provide basic land access and link together to form a network serving the local population. If all of Alberta's roads were joined into a single line they would travel the circumference of the earth almost 4.5 times around. The total land area occupied by our roads and their rights-of-way is more than 4200 square kilometres, approximately three times the combined area of Edmonton and Calgary. Roads and rail lines are also not evenly distributed, being concentrated more in the southern half of the province (Figure 3.39).

Table 3.6

Summary statistics of roads in Alberta

Road Type	Length (kilometres)	Right-Of-Way width (metres)	Area (square kilometres)
Primary highway - multilane divided	1,664	100	166
Primary highway - 2-lane	12,791	40	512
Secondary highway - 2-lane	15,456	40	618
Local roads	148,562	20	2,971
Total	178,473		4,276

Note: Local roads include improved and unimproved local municipal roads.
Source: 1997 digital map files, Alberta Environment

Figure 3.39

Alberta's Transportation Network

Rail lines operating in Alberta consist of mainline, branch line, rail yards, industrial tracks and sidings. The total length of Alberta mainline track operated by the Canadian National and Canadian Pacific Railways in 1995 was 4445 kilometres. The addition of branch lines, industrial tracks and siding increases the total to almost 8800 kilometres (1996 digital map files, Resource Data Division, Alberta Environment). Given an average right-of-way width of 30 metres, the total area occupied by rail lines in the province is only about 265 square kilometres. The major commodities moved in Alberta by train are refined or manufactured gases and fuel, cereal grains, coal, wood pulp and lumber, fertilizers, sulfur and dried vegetables (Statistics Canada 1996a).

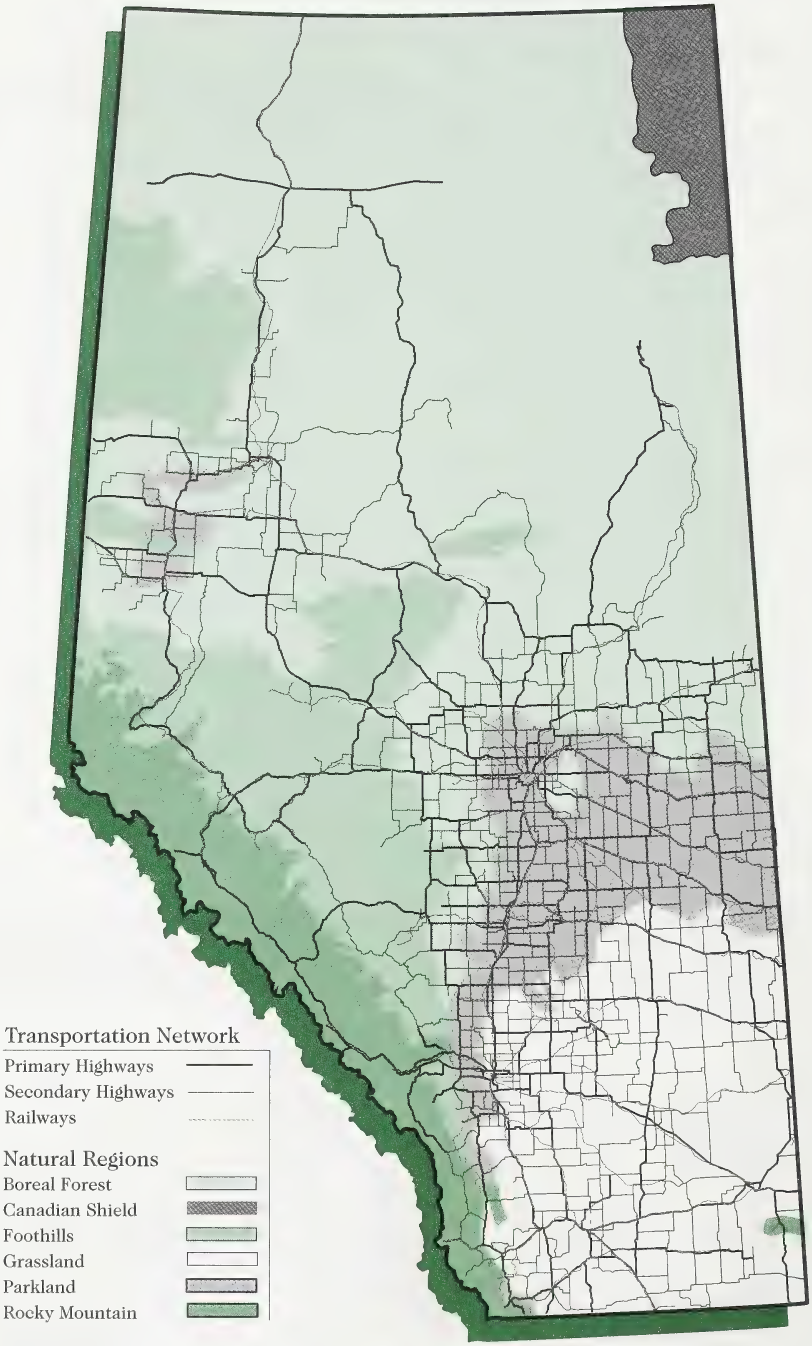
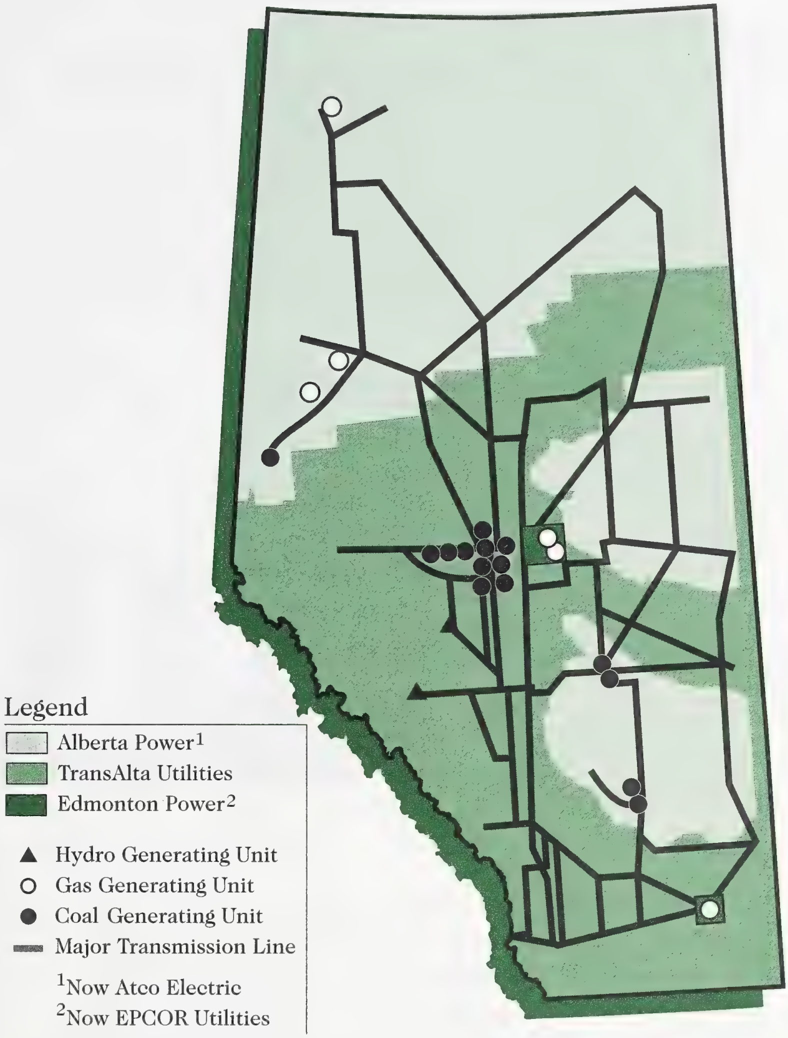


Figure 3.40

Grid System of High Voltage Electricity Transmission Lines in Alberta



Electricity Transmission Corridors

There are three major electric utilities in Alberta — TransAlta Utilities Corporation, Alberta Power Limited, and Edmonton Power (EPCOR). Together, they supply about 98 percent of the province's electricity requirements. More than 83 percent of the electricity generated by Alberta utilities is produced using coal-fired thermal generating stations. The remainder is produced using natural gas, hydro, and wind energy. All the power plants and major electricity consumers, such as industries and urban centres, are linked by a transmission network known as the provincial grid system.

The provincial grid system consists of almost 20 000 kilometres of high voltage transmission lines over 60 kilovolts. These corridors spread to most areas of the province, but typically reach higher densities in the more settled areas (Figure 3.40). Over the last few years, the grid system has increased in size to keep pace with industry growth and urban expansion. The total distance of electricity transmission lines (over 60 kilovolts) in 1995 was 19 979 kilometres (Alberta Energy and Utilities Board 1996d). With an average right-of-way width of about 35 metres, this grid system currently occupies a total of approximately 700 square kilometres, or 0.1 percent of the provincial land area. About one-half of these corridors are located in the Green Area and, to a large extent, required tree clearing for their construction. The rights-of-way are kept clear by the application of herbicides (in some cases) and by the mechanical removal of trees to encourage shorter plant species.

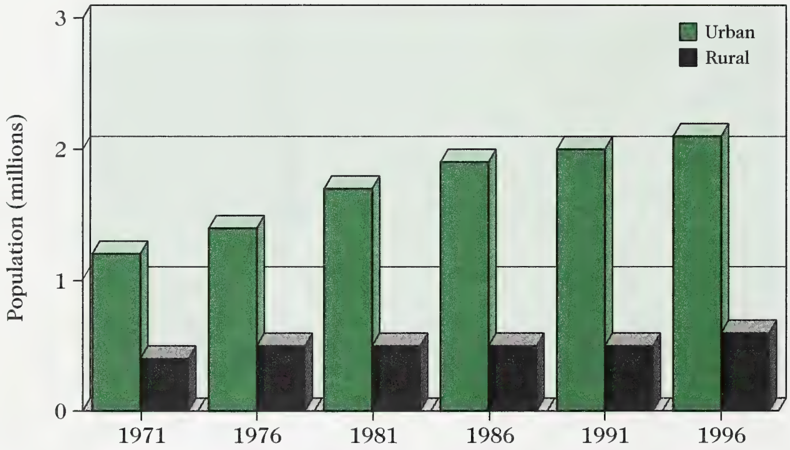
3.4.2 Agents of Change

Urban Growth

As discussed previously, the total amount of the provincial land area occupied by urban centres is relatively small. In terms of demographic trends, however, Alberta is becoming a more urban province. Over the last 25 years, Alberta's urban population has increased markedly, while the rural population has remained relatively unchanged (Figure 3.41). During that 25-year period, Alberta's urban population grew by 1.0 million people, accounting for about 93 percent of the total population increase in the province. This trend is not unique to Alberta, and is occurring across Canada (Government of Canada 1996).

Figure 3.41

Total Urban and Rural Populations in Alberta, 1971 to 1996

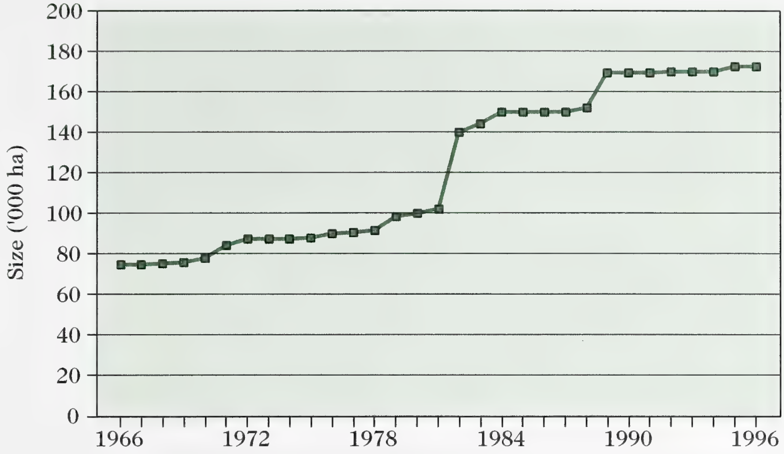


Source: Statistics Canada, Census of Agriculture 1996

Urbanization in Alberta is distributed unevenly, with the most significant growth occurring in and around a few major centres. Within these larger municipalities, residential use typically consumes the greatest amount of land and is the most important factor contributing directly to urban sprawl (Warren *et al.* 1989). Between 1966 and 1996, the cities of Edmonton, Calgary, Red Deer, Lethbridge and Medicine Hat combined grew from 75 000 hectares to almost 173 000 hectares (Figure 3.42). There are also smaller urban areas in the province which have experienced recent rapid growth, although the total land area affected is much smaller than for cities. In terms of human population, there were eight Alberta towns ranked in the top 50 municipalities in Canada for the greatest percentage of population growth between 1991 and 1996 (Statistics Canada 1997b). Most of these municipalities are located near Calgary. Both Canmore and Cochrane ranked in the top 10 fastest growing populations in the country.

Figure 3.42

Total Area of Lands Annexed by Five Alberta Cities, 1966 to 1996



Note: Not all annexed land has been converted to urban uses.
Source: Cities of Calgary, Edmonton, Red Deer, Lethbridge, Medicine Hat

Sometimes urban centres are located in environmentally sensitive areas, and urban sprawl results in considerable concern over balancing the needs of development with the desire for protecting important natural values. For example, the towns of Banff and Canmore are located along the Bow River valley, which is considered a significant area in the montane natural region. This area is both ecologically important and sensitive, providing critical habitat for rare plants and a number of wildlife species. However, both towns have recently experienced rapid commercial and residential growth. Banff is located within a national park, and is under considerable pressure to accommodate an expanding tourism industry. Rapid urban growth and commercial recreation development places increasing pressure on the area's natural ecosystems.

Similarly, in the last decade Canmore has developed several major subdivisions next to the town core. The present property and tourism boom has raised concerns for important habitats in the Bow River valley near the Canmore town site. Although not typical of all urban areas in Alberta, Banff and Canmore represent two of the more publicized examples of urban growth in environmentally sensitive areas.

Other influences of modern urbanization include the use of transportation corridors and recreational lands near urban areas. As urban areas and their human populations expand outward, so too does the traffic on roadways connecting these centres to surrounding areas. Large volumes of traffic contribute to road expansions and habitat losses, as well as local reductions in air quality. Growing urban populations also create additional demands for outdoor recreation in areas that may already be experiencing heavy seasonal use.

Conversion of Lands to Urban Areas

An inevitable consequence of urban expansion is the conversion of adjacent land and its natural ecosystems. One of the most significant forms of land use change resulting from urbanization in Alberta is the conversion of agricultural lands. Historically, agriculture and human settlements have always been closely related, which is why most major cities in Alberta are located on good-quality agricultural land.

In assessing the quality of land, the Canada Land Inventory (1976) classified landforms and soils according to their capability for agricultural use. Classes 1, 2 and 3 are considered the best quality agricultural lands for cereal and oilseed crops. Almost all of the area in the vicinity of Alberta's five major cities (Edmonton, Calgary, Red Deer, Lethbridge, Medicine Hat) is class 1, 2 or 3 agricultural land.

Over the 20 years from 1966 to 1986, Alberta's five major cities converted almost 52 000 hectares of rural land to urban uses. This was 17 percent of the total land converted in Canada during that period, the second highest conversion rate after Ontario's (Warren *et al.* 1989). Some 61 percent (31 400 hectares or 485 quarter sections) of the total rural land converted in Alberta was classified as prime agricultural land. Since 1986, the same five cities have annexed an additional 22 600 hectares of rural land. Although data are not yet available, the Canada Land Inventory maps suggest that a large portion this was likely good quality agricultural land.

Urbanization in large cities is not the only source of rural land conversion. Land conversion in smaller cities, towns and country residential development can also have a significant impact on agricultural lands. The effects of country residential development are spread around the fringe of most urban centres. They result in increased traffic flow, with accompanying wildlife-vehicle collisions, and also contribute to habitat fragmentation. Between 1976 and 1995, the total amount of agricultural land converted by residential subdivision was 81 920 hectares (Alberta Agriculture, Food, and Rural Development 1998). In particular, the more populated areas between Edmonton and Calgary along the Highway 2 corridor have experienced significant growth and land conversion.

The adverse effects of urbanization and land conversion in Alberta are not confined to agricultural lands. The conversion of natural landscapes and ecosystems is another important consideration because of their diverse ecological effects. Urban sprawl often removes woodlands and other natural vegetation, disrupting wildlife corridors and destroying natural habitats. Wetlands are typically drained, filled and converted to other uses. The remaining streams and other aquatic habitats may have their natural functions impaired or altered by the effects of urban runoff and developments along their banks. Environmentally

significant areas, such as river valleys with critical wildlife habitats, are often threatened or reduced in size by urban developments.

In summary, urbanization is a highly intensive form of land use that converts most of the natural ecosystem functions and renewable resource uses where it occurs. Because of the high concentration of people, automobiles, buildings and other infrastructure that it involves, urbanization usually has a disproportionately high impact on productive agricultural land, prime wildlife habitat, aquatic systems, woodlands and other components of regional and local ecosystems (Government of Canada 1996).

Urban Pollution and Wastes

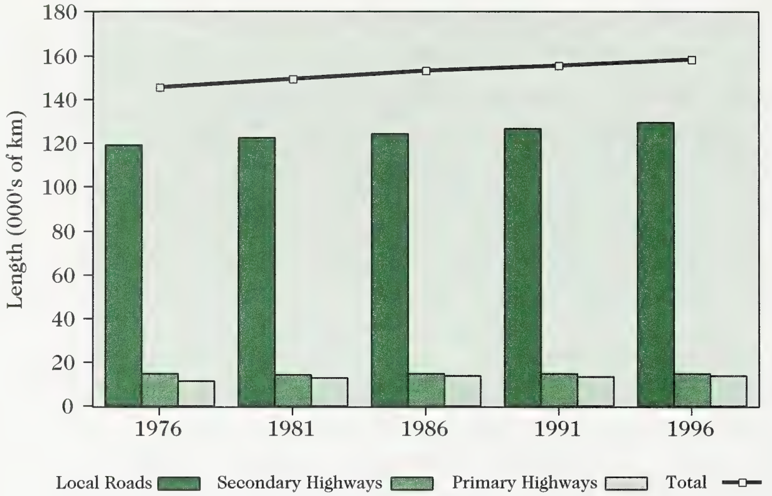
The "urban ecosystem" is a major consumer of natural resources and manufactured goods, producing large volumes of waste products as a result. There are a number of well-documented environmental problems associated with urban centres, most notably the larger cities. Many of these are problems related to air pollution, water quality deterioration, noise pollution, and the generation of solid wastes. (The topic of solid wastes can be explored further in the *Alberta 1995 State of the Environment Report - Waste Management*. The 1996 report dealt with aquatic ecosystems and water quality in detail, and a future report will discuss the subject of air quality in the province.)

Use of Transportation Corridors

Dedicating land as transportation corridors is an integral part of the development of modern transportation systems, and Alberta's transportation network is expanding (Figure 3.43). The expansion of these systems in Alberta parallels long-term urban and economic growth, as well as an increase in the number of vehicles using the road network. The number of passenger automobiles in the province has shown a steady increase since 1981 (Figure 3.44). In 1995, registration statistics indicated that Alberta had more than 1.5 million passenger cars and almost 350 000 trucks and truck tractors (Statistics Canada 1996b, 1996c). The number of passenger automobiles per capita, 563 per one thousand people, was the highest in Canada. To fuel our love for the automobile, Albertans burned more than 3.9 billion litres of gasoline in 1995.

Figure 3.43

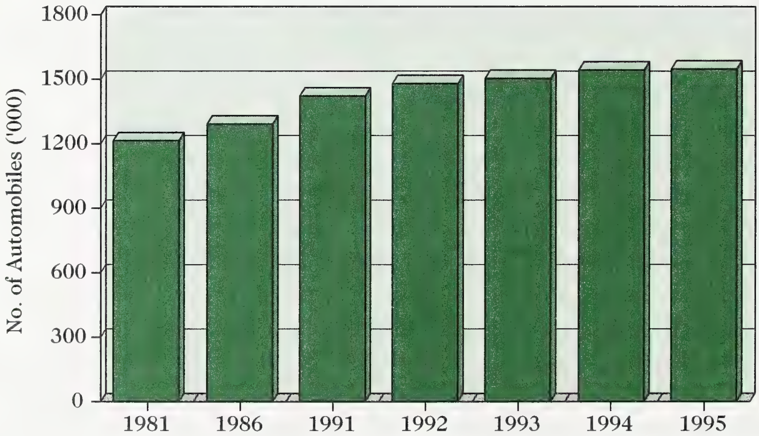
Total Length of Major Road Types in Alberta, 1976 to 1996



Note: Excludes the following roads: Federal jurisdiction, cities and private
Source: Alberta Infrastructure

Figure 3.44

Number of Passenger Automobiles Registered in Alberta, 1981 to 1995



Source: Statistics Canada 1996

The widespread ownership and use of passenger cars has brought Albertans important social and economic benefits. Some of the environmental effects of automobile use are related to fossil fuel consumption and atmospheric pollution. However, there are also other environmental implications of a heavy reliance on automobiles. Some transportation corridors funnel high volumes of traffic through sensitive ecosystems and habitats. The ensuing effects are particularly evident in river valleys, foothills and mountainous areas. Problems include excessive noise, collisions with wildlife, fragmentation of natural habitats, avoidance of important habitat areas, and reduced habitat effectiveness near busy corridors. They also include roadside ditches that can become bedding grounds for weeds that can spread into adjacent agricultural fields and natural habitats.

3.4.3 Actions

This section discusses some of the steps being taken to promote more sustainable urban development and land use conversion, and to ensure a place for natural ecosystems in urban areas.

Urban Land Use Planning

Urban centres in the province are growing, and will likely continue to do so in the decades ahead. However, it is recognized that there is a problem with how and where this growth is occurring. To accommodate population growth over the past several decades, Canadian cities have expanded with new suburbs — a process that converts land at a rapid rate (Government of Canada 1996). Many cities across Canada, including in Alberta, have now begun to place more emphasis on increased housing in the downtown core, as well as redevelopment and housing construction in existing built-up areas. Sustainable land use places more emphasis on the intensification and efficiency of land development, combined with restoration and protection of natural areas (City of Calgary 1997).

Effective land use planning also involves setting long-term goals and objectives for the transportation network. Municipalities have a great deal of control over transportation systems within their boundaries. Land use planning that promotes compact development without the sprawl typical of automobile-dependent suburbs is one way in which cities can reduce the distance their inhabitants must travel. Also, public transit can be promoted as more economical and convenient in areas with higher population densities. An interconnected trail system for pedestrians and cyclists is another means of reducing the number of automobiles on urban roadways and, in turn, reducing atmospheric emissions from automobile exhaust. For example, Banff now operates its Explorer Transit Service, and encourages the use of alternative transportation by developing its pedestrian and bicycle routes.

Municipal-Provincial Land-Use Policies

Land-use planning is both a municipal and a provincial activity. Land-use planning decisions must balance a variety of economic, social and environmental interests, and works best when consistent and coordinated at both the provincial and municipal levels. To address this need, land-use policies were established in 1996 under the *Municipal Government Act* (Alberta Municipal Affairs 1996). The document *Land Use Policies* helps municipalities harmonize provincial and municipal policy initiatives and the local land-use planning level. The policies are intended to achieve orderly development that recognizes the differences between, and benefits of, competing land uses. Each municipality is expected to incorporate the policies into its planning documents and practices.

Most of the policies are designed to apply to specific land-use planning issues in which the province and municipalities share a common interest. These include land-use patterns, the natural environment, resource conservation (agriculture, water, historical and non-renewable resources), transportation and residential development. The overall goal for guiding land-use patterns is "to foster the development of land use patterns which make efficient use of land, infrastructure, public services, and public facilities; which enhance economic development activities; which minimize environmental impact; which protect significant natural environments; and which contribute to the development of healthy, safe and viable communities"(Alberta Municipal Affairs 1996).

To help municipalities in land-use planning, Alberta Environment offers a reference manual to help municipalities review environmental aspects of proposed subdivisions. Under the *Municipal Government Act*, a subdivision authority must not approve a subdivision application unless the land is suitable for that purpose. Environmental concerns play a key role in determining the suitability of land for a subdivision. The Environmental Reference Manual provides planners and development officers with tools that can help them to detect, avoid, and resolve environmental concerns related to subdivision applications (Alberta Environmental Protection 1996c). The manual also helps pinpoint when a proposed development will likely need approvals or authorizations under the *Environmental Protection and Enhancement Act*, *Water Act* and *Public Lands Act*.

Planning and the Environment

Alberta's major cities are becoming more involved in long-term environmental planning. For example, the City of St. Albert is currently developing an environmental assessment process for reviewing development proposals on municipal lands. The Environmental Master Plan (EMP) will help the city develop in an environmentally responsible way. Topics analyzed in the EMP include solid waste reduction, a new landfill site, reduction of pollution in the Sturgeon River valley, water conservation, air quality, chemical use, and public education on environmental issues.

The City of Red Deer has developed an Environmental Action Plan that identifies the most important environmental issues in the city for the near future. The plan outlines actions and financing to deal with the issues, and discusses the need for a balance between environmental protection and preservation, and support for the business community. Some strategies include preserving natural areas and maximizing green space, and supporting programs that increase awareness and public involvement in environmental management.

Developing Urban Parks

In 1979, the Alberta government initiated the Urban Parks Program. Studies showed that urban dwellers had an overwhelming need for contact with the natural environment — a trend that has become even more apparent today. The Urban Parks Program was to develop urban parks that were more consistent with nature, leaving more natural areas in cities in a natural state, both for aesthetic and economic reasons. The overall goal of the program was "the establishment of significant areas of open space to ensure urban populations have easy access to natural environments and the development of these areas to ensure their sustained and unimpaired use for outdoor recreation."

Although recently discontinued, the Urban Parks Program has granted funds to a number of urban municipalities in Alberta for the development of trail systems, nature interpretation centres, and other associated facilities. As a follow-up to this program, the City of Calgary is now completing its Urban Park Master Plan. The plan will promote passive, low-intensity, informal activities; rehabilitate or re-establish natural sustainable landscapes and ecosystems; and limit high-intensity uses to appropriate areas. There are currently about 6500 hectares of parkland overall in Calgary.

The City of Edmonton has prepared the Ribbon of Green Concept Plan and a Master Plan. These plans have established guidelines for the long-term development, use and care of the entire North Saskatchewan river valley system. Physical factors and biological sensitivities were used to create a resource classification system for a land management unit classification. Suitable recreation activities, construction practices, and management practices within each of the management units were identified. With the exception of certain areas, the plans limit development to an integrated trail system for hiking, cycling and cross-country skiing. These trails make the river valley accessible to the public while protecting its natural landscape and wildlife habitat areas. Edmonton boasts that its ribbon of green is the longest stretch of urban parkland in North America, encompassing an area of more than 7400 hectares (City of Edmonton 1997a).

Nature Conservation and Biodiversity

In the past, nature conservation and biodiversity in cities were usually emphasized within an urban park system. This system could vary widely in form, from well-manicured green spaces to more natural habitats. In more recent years, the emphasis has been to leave and preserve natural areas intact. For example, the City of Calgary developed a Natural Area Management Plan in 1994, which protects and manages natural areas within the city limits. Essentially a master plan for preserving natural areas and environmental reserves within the City of Calgary, its conservation principles were incorporated from documents

such as the Urban Park Master Plan and the Sustainable Suburbs Study. The new strategies were implemented successfully in 1997. A landscape ecology approach guides the new plan. This focuses on protecting the viability of Calgary's natural resources (vegetation, topography, soils, and ecological systems) over the long-term. Performance measurements were developed to monitor the effectiveness of the plan. A healthy functioning natural system, with a balance of public use and enjoyment of the areas, is its ultimate conservation goal (City of Calgary 1997).

Calgary has also recently completed a number of companion projects to its Natural Areas Management Plan. The projects will supply information necessary for setting the plan's objectives. One important study was an inventory of environmentally sensitive areas (ESAs), identifying factors, such as significance, condition, size, ownership, and public use. These types of inventories have become more common in the long-term planning for green spaces in Alberta's urban areas. Other urban centres in Alberta have undertaken similar programs and studies to promote nature conservation and protect natural biodiversity within the urban landscape.

Education

Many of Alberta's urban centres run public education programs to promote environmental awareness. The majority of these education programs focus on issues dealing with toxic wastes, recycling and waste reduction, environmental lifestyles and environmentally friendly alternatives. Other programs promote environmental education through nature walks, ecology camps, and sessions about endangered species and vanishing ecosystems, to name a few. Events such as Clean Air Day, Earth Day and Environment Week are becoming more common in Alberta cities — all are designed to foster environmental awareness and responsibility.

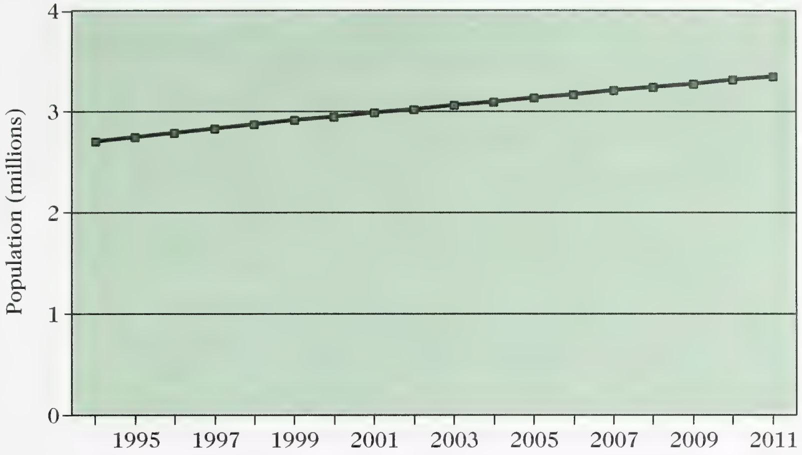
3.4.4 Future Directions

Population

For Alberta, population growth is greatly influenced by employment opportunities in Alberta's resources industries, triggering migration from other parts of the country. With good prospects for continued economic prosperity, Alberta's population will likely continue to grow, inspired by a healthy economy and attractive social and natural environments. Alberta's population is projected to grow at a rate of about 1.27 percent to 3 353 110 people by the year 2011 (Figure 3.45) (Alberta Treasury 1997). This would constitute an increase of approximately 23 percent over 1994's population in just 17 years.

Figure 3.45

Projected Provincial Population Growth



Source: Alberta Treasury 1997

Alberta cities will continue to enjoy much of this growth as the trend toward a more urbanized population continues. This is supported by studies in individual Alberta cities. For example, between 1991 and 2024, Calgary's population is projected to increase by 542 000, to approximately 1.25 million people. Nearly all of this growth is expected to occur in the suburbs (City of Calgary 1995). The City of Edmonton Metropolitan Area population is projected to grow to more than 936 000 people by the year 2002 (about 1.4 percent annually) (City of Edmonton 1997b). A medium growth rate of one percent is projected for the City of Lethbridge.

Much of the urban growth in Alberta cities can occur within existing city limits, reducing the amount of undeveloped land within the community. However, at some point additional lands will probably be annexed to increase the city land base. As city populations grow, their "ecological footprints" increase. More people corresponds to additional housing, increased resource consumption, more traffic, greater quantities of solid waste and sewage, and so on.

Current urban land development and property tax policies in Canada encourage automobile-dependent urban sprawl (National Round Table on the Environment and the Economy 1997). However, the cost of urban sprawl is causing some to re-think how our cities grow. At 721 square kilometres, the City of Calgary is Canada's second largest city. Its Transportation Plan proposes an increase in the average density of residences from 12 units per hectare to 17 (City of Calgary 1995). A higher density will reduce land requirements and produce a more compact community. In addition, new suburbs will be designed to encourage people to walk, bicycle or use public transit.

Ecological Footprint

Cities occupy a relatively small land base, but they draw on the ecological resources of the surrounding region and beyond for such items as food, water and waste disposal. The ecological footprint of a city is the hypothetical area of land that would be needed to supply the community with these resources. (See Rees and Wackernagel (1996) for further discussion of this concept.)

Country residential development (acreages) will probably continue to proliferate around Alberta's urban centres. These residences offer a form of "country living," with easy access to nearby city amenities, like shopping, entertainment, and employment. The low density of these developments means that more land will be used per dwelling and infrastructure needs, such as roads, sewers, and utilities. However, acreage developments often sustain many natural features and habitats that would be removed by complete urban development.

Transportation and Utilities

The need for transportation and the demand for energy increase with population growth and industrial development. Alberta's highway network is well established and with ongoing maintenance and upgrading, should meet the province's future needs. However, some new roadways may be built to serve future resource developments. In rural areas, some roads may be converted from two lanes to freeways with interchanges and service roads. Many narrow, gravel roads may also be upgraded to a higher standard. Ring roads around Edmonton and Calgary may be completed to direct regional traffic around these large cities.

Future plans for major provincial transportation routes include upgrading Alberta highways in the CANAMEX corridor, a proposal to improve truck travel along the north-south corridor from Alberta to Mexico. This project includes parts of Highways 43, 16, 2, 3 and 4 between Grand Prairie and the Canada-United States border at Coutts. Scheduled upgrading and widening will eventually convert the entire corridor to four-lane standards (Alberta Transportation and Utilities 1997).

Electric utilities will also continue to grow as demand increases. Alberta's current infrastructure of generating stations and transmission lines will probably serve the province well into the future. However, the recent restructuring of the electrical utility industry in Alberta may mean future changes in how power requirements are met. For example, large industrial facilities may construct on-site or nearby generators, selling any surplus electricity into the grid (transmission network). This would reduce the need to expand the main grid infrastructure.

3.5 Recreation and Protected Areas

Unlike many other land uses, protected areas and areas for recreation usually have a minimal effect on the natural functions and processes within terrestrial ecosystems. This is by design. Protected areas and areas for recreation are an important land use that helps protect the environment and provides the public with an opportunity to appreciate Alberta's natural heritage.

At the broad level, these areas contribute to the protection and conservation of natural resources, and to outdoor recreation and tourism, heritage appreciation and the preservation of biodiversity. Many protected areas have very specific benefits for individual people, such as the wilderness experience provided by a remote, undeveloped terrestrial ecosystem that has kept its natural character. Other areas closer to urban centres offer excellent opportunities for nature interpretation and education. Fully-protected areas that exist as intact, functional ecosystems are also important as natural areas for scientific research and as benchmarks for monitoring the effects of other land use activities nearby.

3.5.1 Present Conditions

There are several different types of recreation and protected areas in Alberta. They differ in their purpose and level of protection, and in recreation and tourism opportunities they offer. The *Provincial Parks Act*, the *Willmore Wilderness Park Act* and the *Wilderness Areas, Ecological Reserves and Natural Areas Act* offer six legal classifications of recreation and protected areas in Alberta. These classifications form a broad spectrum, from highly protected sites - like the White Goat Wilderness Area - to simple roadside rest-stops. National parks in Alberta are legislated under the *National Parks Act*. (See Table 3.6 for a summary of both the national and provincial designations, and the area they occupy in the province.)

Under the Alberta *Wildlife Act*, several types of wildlife sanctuary can be created. Designated wildlife sanctuaries, game bird sanctuaries and corridor wildlife sanctuaries are used to prohibit hunting in these areas, but otherwise allow normal public access. Seasonal sanctuaries, used for example to protect island colonies of cormorants and pelicans during the nesting season, are more restrictive and prohibit public access during the summer. In habitat conservation areas, a variety of user activities can be restricted, allowing activities that are compatible with the conservation objectives.

National Parks

National parks are representative examples of the natural regions of Canada set aside to protect their flora, fauna and other natural features. Typically, they

provide a high level of protection for their natural resources, but recreation and tourism are often given a high priority. There are five national parks in Alberta: Wood Buffalo, Banff, Jasper, Waterton Lakes and Elk Island. The largest, Wood Buffalo National Park, spans the Alberta-Northwest Territories border, and occupies about 35 000 square kilometres of northern Alberta.

National Wildlife Areas

National Wildlife Areas are relatively new protected areas, designated by Order-in-Council under the *Canada Wildlife Act* (1973). They include wildlife management and multi-use areas, with regulations specific to each one. Most national wildlife areas are on federal land and are dedicated to providing or enhancing habitat for waterfowl, upland game birds, or game mammals. In addition to conservation, most of these areas provide research and education opportunities. Most other public uses and commercial activities are prohibited and/or highly regulated. There are four national wildlife areas in Alberta: three upland sites (Middle Sand Hills, Blue Quills, and Meanook), and one wetland site (Spiers Lake). Middle Sand Hills is the most significant of these thanks to its unique landscape and large size — 42 000 hectares.

Table 3.7

Types of legislated protected areas in Alberta and a brief summary of their principal goals

Classification	Number	Total Area (square kilometres)	Goals
National Park	5	53 183	Preserve all natural features; recreation and tourism values are sometimesgiven a high priority
National Wildlife Area	4	424	Protect or enhance habitat for waterfowl, upland game birds, or game mammals.
Ecological Reserve	15	293	Preserve and protect functioning ecosystems for scientific research and education
Wilderness Area	3	1000	Preserve unspoiled landscapes; include large areas with no human developments; low-impact outdoor recreation
Provincial Park	65	1495	Preserve landscapes, heritage appreciation, outdoor recreation, and tourism; all goals to varying degrees at each park
Wildland Park	4	6117	Preservation and heritage appreciation, with some forms of low impact recreation and tourism
Provincial Recreation Area	301	732	Sustain a wide range of outdoor recreation opportunities in natural, modified or man-made settings
Natural Area	155	868	Protect natural values, education, nature appreciation and low intensity outdoor recreation
Habitat Conservation Areas	4	44	To manage for conservation values; carefully managed multiple use

Ecological Reserves

Ecological reserves are areas selected as representative or special natural landscapes and features of the province. These areas are protected as examples of functioning ecosystems, gene pools for scientific research, and for education and heritage appreciation. There are two types of ecological reserves: Representative Ecological Reserves contain examples of the province's natural regions, whereas Special Ecological Reserves protect biological or geological features that are rare or unique. By emphasizing nature conservation, ecological reserves are part of Alberta's commitment to a larger worldwide conservation strategy.

Wilderness Areas

Wilderness areas are large tracts of undeveloped land retaining their pristine character and influence without permanent disturbance or human habitation. Alberta's three wilderness areas — Ghost River, Siffleur, and White Goat — were established in the 1960s to protect the unspoiled beauty of the mountains, valleys and streams located in the eastern slopes of the Rocky Mountains. All three make significant contributions to preservation, and — to a lesser extent — to heritage appreciation, outdoor recreation and tourism. Wilderness areas are relatively unaffected by human influences, and contain no developed trails or campsites. Visitors explore a wilderness setting where they experience solitude and interact with nature.

Provincial Parks

Alberta's 65 provincial parks protect provincially significant natural, historical and cultural landscapes and features. They provide excellent opportunities and facilities for a wide range of outdoor recreation activities and are perfect places to learn about the natural world. Many provincial parks have interpretive programs, which include guided hikes, amphitheatre programs, special events, and self-guided nature interpretation trails.

The parks vary in size, from Peace River's Twelve Foot Davis Park at less than one hectare, to Peter Lougheed Provincial Park which covers over 500 square kilometres. Several parks make outstanding contributions to the goals of preservation, heritage appreciation, recreation and tourism. Alberta's provincial parks are found primarily throughout the settled area of the province.

Wildland Parks

Established under the authority of the *Provincial Parks Act*, wildland parks are relatively large areas of undeveloped land that retain their natural character. Human developments and interference with natural processes are kept to a minimum. There is no intensive recreational development in wildland parks, although they typically have primitive back-country campsites and foot trails.

Three such parks have been designated in Alberta — Elbow-Sheep, Kakwa and Fort Assiniboine Sandhills. Willmore Wilderness Park is also considered a wildland park, but was designated under its own special legislation — the *Willmore Wilderness Park Act*.

Provincial Recreation Areas

Most of Alberta's 301 provincial recreation areas include sites originally developed by different provincial government agencies including Alberta Infrastructure and Alberta Environment. Most sites are small and were developed primarily as recreation facilities. Nonetheless, there are notable exceptions that include important natural landscapes. For example, the Evan Thomas Provincial Recreation Area in Kananaskis Country (44 square kilometres) has a number of popular recreation facilities including a golf course and ski hill, but also includes several trails into the backcountry and some significant wildlife migration corridors.

Natural Areas

Natural areas fall in the middle of the range of conservation lands in Alberta, between lands under relatively strict protection (such as ecological reserves), and lands intensively developed for recreation. The main objective of natural areas management is to maintain the natural characteristics of a site, while allowing a moderate level of public use. Many natural areas are used for cross-country skiing, hiking, bird watching, fishing and nature observation.

Natural areas in Alberta vary in size from 0.6 hectares at Antler Lake Island Natural Area to the Rumsey Natural Area, which encompasses almost 150 square kilometres. The majority of Alberta's natural areas can be found in the settled area of the province.

Focus Issue — Protected Areas and Biodiversity

Protected areas are internationally recognized as one of the cornerstones in the conservation of biodiversity. Representative protected areas serve as ecological benchmarks — places where ecological processes proceed in a relatively undisturbed fashion. This makes them valuable for scientific research and gene conservation. At the same time, for biodiversity preservation to be successful, protected areas cannot exist as small "ecological islands" surrounded by developed lands. Management of protected areas must therefore be accompanied by the wise stewardship of surrounding lands to give species that use large areas the chance to disperse and interact. Finally, the level of protection must ensure that biological diversity is retained over the long term.

In Alberta, the landscape classification framework for Natural Regions and Subregions has been adopted to describe the environmental diversity of the province. Using the framework to classify and protect a full range of landscapes or habitats in the province should help preserve most of the biological diversity that depends on those landscapes. The framework also helps to evaluate existing protected areas to determine which elements of biological diversity are included, and where gaps remain. The Natural Areas framework is based on natural or biogeographic features such as geology, landform, soils and hydrology. Other factors affecting classification include regional climate, vegetation and wildlife. (see Section 2.1)

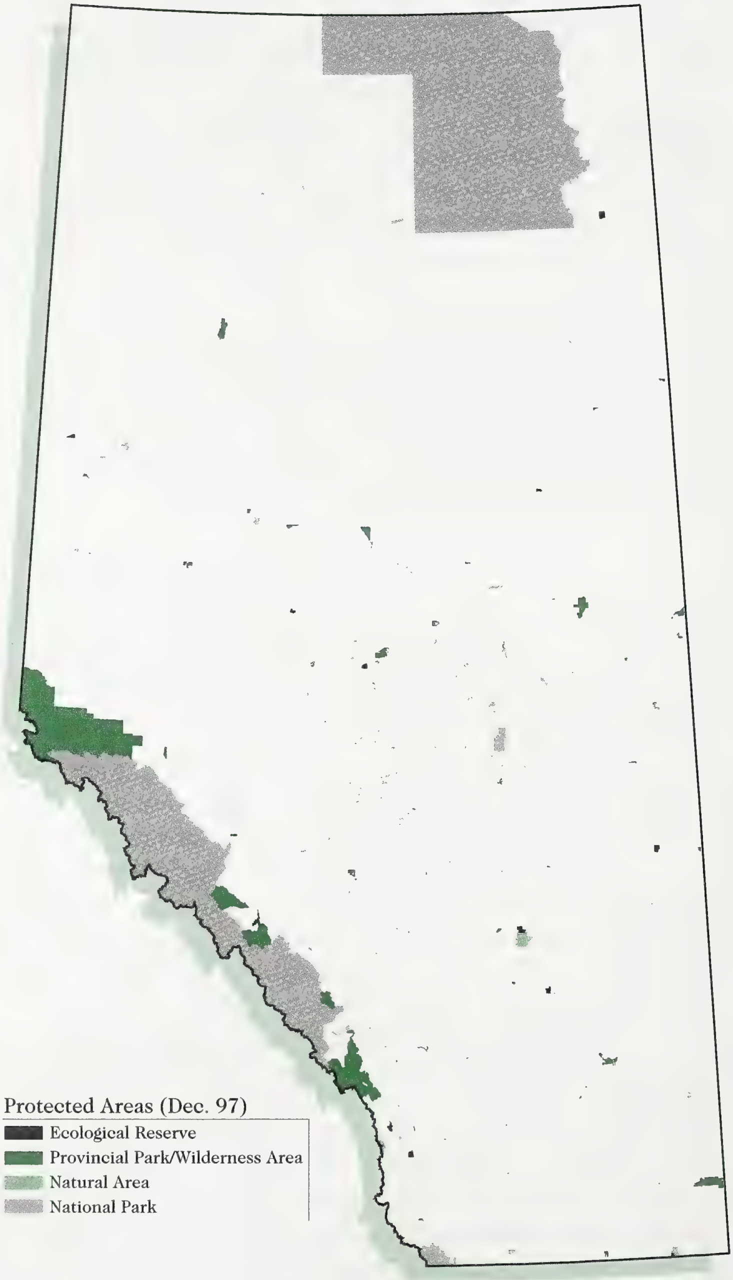
Alberta's Special Places policy is the basis of the provincial protected areas strategy. This initiative is designed to complete a network of protected areas that represent the biological diversity of the province's six natural regions, and 20 subregions. One of the four main goals of this policy is preservation — "to designate natural landscapes that preserve the full range of environmental diversity and special natural features of Alberta" (see Section 3.5.3).

Alberta's current system of protected areas covers approximately 6.5 million hectares — 9.5 percent of the province (Figure 3.46). The majority of this land is located in national parks (5.4 million hectares) with the balance being protected through some form of provincial designation as described previously.

The network of protected areas and areas for recreation contributes meaningfully to the quality of life of Albertans — both as examples of the provinces natural beauty and as recreation destinations for millions of visitors every year. In 1996-97, close to nine million people visited provincial parks and recreation areas (visitor data are not collected for ecological reserves, wilderness areas and natural areas). Of all the recreation areas and parks under provincial jurisdiction, Kananaskis Country District and Fish Creek Provincial Park (day use only) routinely receive the greatest use, accounting for approximately 55 percent of total park and recreation area visits in 1996-97 (Alberta Environmental Protection 1997a). The high number of visits in these two areas is primarily because of the high number of day users, and the close proximity of the areas to Calgary. Fish Creek Provincial Park is within Calgary's city limits, and three parks in the Kananaskis Country district are within a one-hour drive from the city. Visits to national parks in 1996 included some six million entries by vehicles and 15 million people — 95 percent of these entries occurred in Banff and Jasper (Canadian Heritage, Business Services Group, 1996 attendance statistics).

Figure 3.46

Distribution of Protected areas in Alberta



Parks and other protected areas make notable contributions to the Alberta economy. In 1993-94, visitors to the national parks and the major provincial parks in Alberta spent about $1.2 billion on goods and services related to their visits. These expenditures directly and indirectly contributed to $975 million in GDP and 22 260 person-years of employment (Dobson and Thompson 1996).

3.5.2 Agents of Change

The range of protected area legislation in Alberta allows differing types and levels of development, from none to intensive. Oil and gas exploration and extraction is permitted in 94 of the province's natural areas, and has occurred in 88 of them. Currently, oil and gas wells exist in seven provincial parks and in five ecological reserves, although additional industrial activity is not permitted in ecological reserves once they are established. Logging has occurred in Wood Buffalo National Park, Cypress Hills Provincial Park and Moonshine Provincial Park. Unless properly managed, such industrial activity can disturb the natural ecosystems of designated areas. Other pressures on Alberta's recreation and protected areas network can come from high visitor numbers, recreational use, facility development, and agricultural activity.

Habitat Fragmentation

Habitat fragmentation, discussed briefly in Chapter 3, is a relatively unnatural process whereby once extensive and adjoining ecosystems are broken-up into patches of various sizes and shapes. Fragmentation into smaller habitat patches is a significant threat to biodiversity because it isolates populations and increases the chances of local extinctions (Department of Canadian Heritage 1995). Typically, the most significant cause of fragmentation is human activity that makes large-scale changes to the landscape. The most obvious sign of habitat fragmentation in a given area is the loss of the characteristic ecological communities or dominant vegetation, whether forests or grasslands.

Some of Alberta's parks and protected areas are also showing signs of fragmentation. For example, Fish Creek Provincial Park, a highly developed urban park, is fragmented by heavily used trails, parking lots, day-use areas and other facilities. As well, the effectiveness of habitats within some parks has been altered by well sites, roads, pipeline and transmission line corridors, cutlines and trails.

Isolation

An important external threat to the ecological integrity of protected areas is their isolation from the surrounding landscape due to development on adjacent lands. Isolation can be viewed as an extreme case of fragmentation, where habitat patches across the landscape are no longer connected with each other so that there is little or no interaction between populations of resident plant and animal species. "Island biogeography theory" has been used extensively to predict when habitat fragments have lost their connectedness (e.g., Harris 1984). As with remote islands, a habitat patch's increased isolation reduces the chance for plants and animals to move between patches, and so increases the risk of local species extinction. Smaller patches can support fewer individuals, and smaller populations of plants and animals are more susceptible to local extinction than larger populations (Hunter 1990, Grumbine 1992).

Based on the concept of isolation, smaller and more isolated examples of terrestrial ecosystems would have a higher probability of having some of their natural ecosystem functions being impaired. This could compromise the overall ecological integrity and specific preservation values of the site. This points to the importance of considering the relationship between protected areas and their surrounding multiple-use lands.

These concepts are relevant to a large number of the smaller parks and natural areas in the province. Many of these sites are much smaller than 1000 hectares, and most are located in the extensively altered landscape of the parkland and grassland natural regions.

Intensive Visitation and Recreational Development

The expression "too much of a good thing!" can apply directly to parks and recreation areas that attract a high degree of use. For any park, a balance must be struck between preserving the area's ecological integrity and allowing the sensitive use of its resources for both recreation and economic returns (Government of Canada 1996). Monitoring a site's use and development is one way of determining if some parks may be approaching the point of overuse as tourism and recreation attractions, especially during the peak seasons.

Statistics on visits to Alberta's provincial parks between 1986-87 and 1996-97 indicate that total visits increased 50 percent over the period, from 5.6 million to almost nine million people. There are several reasons for this increase. First, the number of campsites in the province increased from 10 000 units to 12 900 units over the same period. Second, the provincial population grew. Third, the interest in experiencing Alberta's parks may also have increased. And fourth, at least part of the increase may be attributed to a new method for quantifying visits. Introduced in 1988 for the major provincial parks and recreation areas, the methodology has evolved and been phased in over time (particularly for day-use) to include all provincial parks (Alberta Environmental Protection 1997a).

Protected areas and areas for recreation in Alberta have a maximum limit of use, beyond which additional development and use can compromise the features the area was set-up to protect. The parks and recreation areas in Kananaskis Country may have reached that threshold, due to the high number of visits year-round and resource extraction activities within and adjacent to the park. For that reason, there has been a moratorium on further development in K-Country until studies can be conducted to determine if the area can sustain additional use. Fish Creek Provincial Park is another example of intensive use by cyclists and off-trail hikers beginning to have a noticeable effect on vegetation and landforms. Managers of Banff, Jasper and Waterton Lakes national parks periodically close hiking trails in areas of intensive use to allow for reclamation and recovery.

3.5.3 Actions

Special Places

In 1995, the Alberta government announced its commitment to Special Places. Special Places is a strategy to complete a network of protected areas representing Alberta's six natural regions and 20 subregions. Representing the environmental diversity of the province, these areas become part of Alberta's Recreation and Protected Areas system. The priority is to fill in "gaps" in the existing protected areas system with under-represented landscapes. Special Places balances its primary goal of preservation with the goals of outdoor recreation, heritage appreciation, and tourism/economic development. It is anticipated to

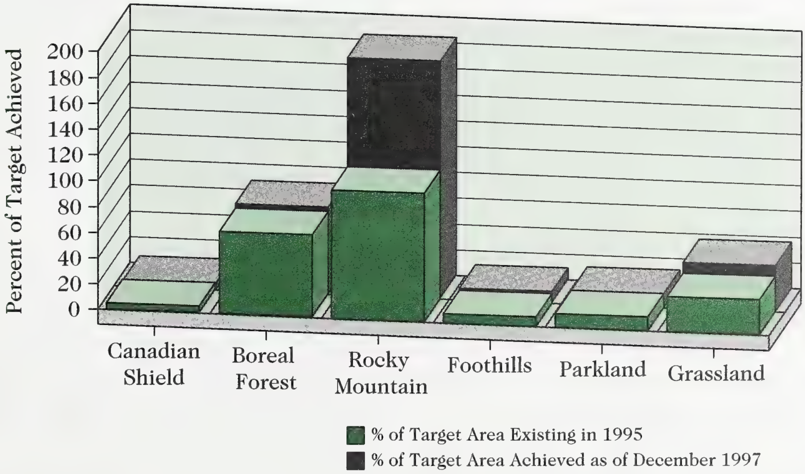
significantly increase the province's protected areas landbase from 62 000 square kilometres to approximately 71 000 square kilometres.

In the three years since the Alberta government first announced the Special Places program, Albertans have shown a great deal of support for Special Places by nominating more than 300 sites. Thirty-seven new areas, representing 10 subregions and a total of 2065 square kilometres, were added to the protected areas network by the end of 1997. (Figure 3.47 shows the progress toward Special Places targets for each natural region since the program began in 1995.)

Fifteen of the new sites are greater than 1000 hectares in size. Some of the larger additions include: Kakwa and Elbow-Sheep Wildland Parks in the alpine and subalpine subregions; Fort Assiniboine Sand Hills and the Cold Lake Provincial Park expansion in the Central Mixedwood; Rumsey Natural Area in the Northern Fescue; and Ross Lake Natural Area in the Foothills Fescue. A multi-stakeholder Provincial Coordinating Committee, in cooperation with Alberta Environment, recommended areas to fill the gaps in the Special Places network. Local committees then examine these sites, confirm their desirability, refine the boundaries, and recommend management strategies.

Figure 3.47

Progress Toward Special Places Targets for Major Landscapes (Level I Theme) 1995 and 1997



Note: For the Natural Regions, such as Boreal Forest and Parkland, the local committees (LC) had not yet been formed. Other LCs are only in the formative stages.

Completing the Puzzle

The province's network of recreation and protected areas continues to grow — 37 new sites were added to the network between March 1995 and June 1997. This network is scheduled for further expansion through the Special Places program before the year 2000, and could triple the total landbase protected by provincial legislation in Alberta. Faced with the challenges of an expanding network, it has become clear that the four goals of the Alberta Recreation and Protected Areas Program — preservation, heritage appreciation, outdoor recreation and tourism — cannot be achieved without bringing a new vision to the management of the network.

"Completing the Puzzle" is a new strategy to meet the Recreation and Protected Areas program goals. By focusing the program on its four objectives, Completing the Puzzle will help fulfil the government's commitment to protect natural, historical and cultural resources. The strategy groups existing sites into two broad categories based on the four objectives. One category includes those sites that protect significant components of Alberta's natural heritage (Natural Heritage Sites). The other category consists of those sites that are almost exclusively for recreation (Recreation Facility Sites), and do not protect significant parts of the province's natural heritage.

Completing the Puzzle complements Special Places, and reinforces the province's commitment to ensure protected areas and areas for recreation are available to Albertans and their children. Through this initiative, the Alberta government will be better able to protect the network as pressures on natural landscapes increase. Fiscal and staff resources will be directed toward intensive resource management in those parks with critical natural heritage features — such as Dinosaur World Heritage Site, Writing-On-Stone, Lesser Slave Lake, Whitney Lakes, Peter Lougheed and William A. Switzer Provincial Parks — that contribute to the program's four goals.

To ensure that outdoor recreation opportunities continue to be made available in a financially responsible way, the Alberta government will continue to give the private sector greater flexibility and responsibility for the delivery of services in Recreation Facility sites. This will ensure that the Alberta government has the resources to preserve our natural wilderness and to manage a growing parks system for future generations to enjoy.

Alberta Natural Heritage Information Centre

Conservation of biological diversity is the cornerstone of the Special Places initiative. However, finding ready access to information on species, natural communities and specific sites has been a major challenge. The Alberta Natural Heritage Information Centre (ANHIC) was established in 1994 to address these

needs. The ANHIC is a collaboration between Alberta Community Development, Heritage Canada and The Nature Conservancy. The centre compiles information about uncommon plant and animal species, and plant communities. This information is then used to help identify priorities for heritage appreciation in Alberta, both inside and outside existing recreation and protected areas. All of the information is housed in a series of linked computerized databases. The system is modelled on the one used in the Conservation Data Centres of The Nature Conservancy.

Reservation and Notation Program

Under the *Public Lands Act*, notations and reservations are used as one tool to identify public lands that are intended to achieve particular land use or conservation objectives. These provide for varying degrees of protection, from complete protection to permitting agricultural, industrial or other uses with land use conditions. The reservation system identifies public lands that are important for soil and water conservation, potential natural areas, significant wildlife habitat, timber production, recreation, and historic sites. More than one protective notation can be placed on a parcel of land. For example, steep slopes along a river may have one notation for unstable, erodible slopes, while a second notation identifies a wildlife corridor in the same area.

Reservations and notations placed on public land alert the land manager to previous reviews regarding the use of that land as well as alerting other potential land users of these concerns. Reviews can be requested of reservations and notations to ensure they continue to be valid.

Some land uses are compatible with the intent of the reservation while others may not. For example, agricultural uses such as grazing may occur and be integrated with conservation objectives on land identified with a protective notation for soil and water conservation. The notation does prevent the land from being applied for sale or annual cultivation.

These designations are recorded in a database maintained by Alberta Sustainable Resource Development. There has been about 2.4 million hectares of land identified through protective notations in the White Area and 6.3 million hectares in the Green Area. While some of these overlap other dispositions and notations, they serve as a major guide for other potential land users as well as the land manager.

International Designations

Nine different sites in Alberta have been designated under international protection programs. Waterton Lakes National Park is designated as a Biosphere Reserve under the "Man and the Biosphere" program of the United Nations' UNESCO.

Four World Heritage Sites are designated under the UNESCO World Heritage Convention: Dinosaur Provincial Park, Canadian Rocky Mountain Parks, Wood Buffalo National Park and Head-Smashed-In Buffalo Jump. Four wetland areas are designated as internationally significant under the Ramsar convention (Whooping Crane Summer Range, Peace-Athabasca Delta, Hay-Zama Lakes and Beaverhill Lake).

These lands already have some form of national or provincial protection as parks or other designation. International designation does not offer legal protection, but the high international profile supports ongoing preservation.

3.5.4 Future Directions

Decreasing number of options for new protected area sites

As its population continues to grow, Alberta's various industrial sectors — and the landbases they occupy or affect — will likely continue to expand, leading to further pressure on wilderness and natural lands. Generally large protected areas have more ecological value and are better able to maintain biodiversity than small protected areas. If the number and size of largely undisturbed areas continues to shrink, the number of options for new protected areas will decrease. This phenomenon is already evident in the heavily settled grassland and parkland natural regions, where few large undisturbed areas remain.

Consolidation of Alberta's Protected Areas Legislation

The purpose of reviewing and consolidating Alberta's protected areas legislation is to develop a new Act and regulations that consolidates protected areas management under a single act that is both streamlined and acceptable to Albertans. This consolidated Act must be capable of meeting the goals and objectives established for Alberta's Recreation and Protected Areas into the next century. The legislation's revision is an important part of the Special Places policy.

The new Act, called the *Parks and Protected Areas Act*, will replace the *Provincial Parks Act*; *Willmore Wilderness Park Act*; and *Wilderness Areas, Ecological Reserves and Natural Areas Act*. A new classification system will be introduced that reflects the IUCN (World Conservation Union) classification system and ensures the system's consistency with national and international protected areas programs. This new classification system for Alberta's protected areas will define the purpose and management guidelines for each protected area class.

Some of the new legislation's basic objectives include the following:

- Clarify the intent of various classes of protected areas so that the public and other interested parties clearly understand the role of the different classes in the overall system;
- Clarify the activities and development that are permitted in each class and that are necessary to achieve the purpose of the class;
- Provide guidelines for resource protection and management to ensure the long-term preservation of Alberta's natural heritage; and
- Eliminate overlap and duplication of existing Acts and Regulations.

Development of Area-Specific Management Plans

Management plans can give overall direction to the development, operation, protection, maintenance and use of protected areas and areas for recreation. More specifically, management plans can define the role of specific recreation or protected areas within the Recreation and Protected Areas system. The plans guide staff and improve public understanding of recreation opportunities and resource management requirements that will ensure the long-term preservation of Alberta's natural heritage. The Recreation and Protected Areas program objectives — preservation, heritage appreciation, outdoor recreation and tourism — are translated into specific management guidelines that can be effectively used for a particular recreation or protected area.

Management plans have recently been completed for areas including Writing-On-Stone Provincial Park, Blackfoot Recreation Area, Hand Hills Ecological Reserve, and Wind Valley Natural Area. In the future, Alberta Community Development will prepare management plans for all protected areas and areas for recreation, and involve the public in the plans' preparation.

4.0
A Natural Region Perspective

A detailed discussion of Natural Regions is necessary to fully understand the state of terrestrial ecosystems in Alberta. Chapter Two introduced Alberta's six natural regions and 20 subregions. Chapter Four examines the regions in more detail and includes the following:

- the size, landforms, climate, soils, vegetation, wildlife and other characteristic features of each natural region.
- the proportion of the region remaining in a natural state;
- total area, number and average size of protected areas; and
- key environmental issues and initiatives within each natural region.

Overview

Alberta's natural landscapes are composed of distinct Natural Regions. The Natural Region classification system groups landscapes with similar landforms, geology, soils, climate, plants and wildlife. There are six Natural Regions in Alberta:

Grassland	Parkland	Foothills
Boreal Forest	Rocky Mountain	Canadian Shield

Within the Natural Regions are 20 subregions, or terrestrial ecosystems, which are defined by similar landscape patterns but which are distinct from the other subregions. Each subregion has several natural history themes that represent the diversity of features found within it. Figure 4.1 shows the relative sizes of Alberta's Natural Regions. The Boreal Forest is the largest natural region, while the Canadian Shield region is the smallest. The area encompassed by each natural region and subregion is presented in Table 4.1.

Figure 4.1

Size Comparison of Alberta's Natural Regions

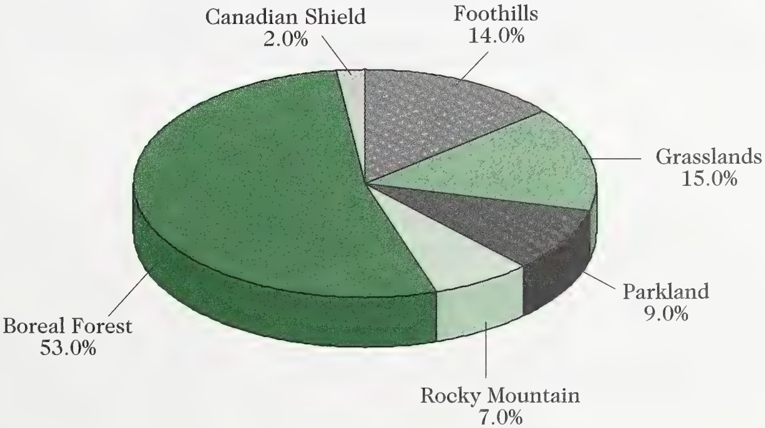


Table 4.1

Area comparison of the Natural Regions and Subregions in Alberta

Region	Subregion	Area (km2)	% of Province
GRASSLAND	Dry Mixedgrass	47 728	7.21
	Mixedgrass	18 243	2.76
	Northern Fescue	15 342	2.32
	Foothills Fescue	14 908	2.25
	Subtotal	**96 221**	**14.54**
PARKLAND	Central	53 265	8.06
	Foothills	4 390	0.66
	Peace River	4 652	0.70
	Subtotal	**62 307**	**9.42**
FOOTHILLS	Lower	65 325	9.88
	Upper	29 204	4.42
	Subtotal	**94 529**	**14.30**
ROCKY MOUNTAIN	Montane	5 971	0.90
	Subalpine	25 692	3.89
	Alpine	14 477	2.19
	Subtotal	**46 140**	**6.98**
BOREAL FOREST	Dry Mixedwood	100 370	15.18
	Central Mixedwood	154 170	23.32
	Wetland Mixedwood	38 333	5.80
	Boreal Highlands	21 179	3.20
	Peace River Lowlands	10 018	1.52
	Subarctic	21 942	3.32
	Subtotal	**346 012**	**52.34**
CANADIAN SHIELD	Athabasca Plain	7 073	1.07
	Kazan Upland	8 903	1.35
	Subtotal	**15 976**	**2.42**
	Total	**661 185**	**100.00**

4.1 The Grassland and Parkland Natural Regions

Although different from a biophysical perspective, the Grassland and Parkland Natural Regions share many similarities when it comes to issues related to terrestrial ecosystems. They are therefore discussed together in this section.

4.1.1 Description

Together, the Grassland and Parkland Natural Regions form Alberta's prairie. They cover 158 500 square kilometres and contain the most densely populated regions in Alberta. Located within these regions are the major cities of Calgary, Edmonton, Red Deer, Medicine Hat, Lethbridge and Grande Prairie. The Parkland region has the highest percentage of land area altered by human activity (estimated at 95 percent), followed closely by the Grassland region. Agriculture is the dominant land-use in the prairies, with crop and livestock production occurring extensively. In addition to agriculture, the grassland and parkland regions have experienced the greatest amount of land conversion to transportation corridors (Table 4.2). To date, more than 80 percent of the native prairie landscape (grassland and parkland combined) has been transformed by a combination of agriculture, industry (primarily energy), urbanization and transportation corridors (Alberta Prairie Conservation Forum 1995). Other important land uses include recreation and tourism.

Table 4.2

Total length and density of transportation corridor types in Alberta's natural regions

Transportation Corridor	Natural Region					
	Grassland	Parkland	Foothills	Rocky Mountain	Boreal Forest	Canadian Shield
Primary Highway - multilane divided	610	653	162	82	157	0
Primary Highway - two lane	2753	3307	1176	903	4,652	0
Secondary Highway - two lane	5280	3893	912	277	5087	0
Local Roads	35 277	38 906	18 557	2569	53 240	13
Railway	2591	2663	688	394	2,448	0
Linear Distance (kilometres)	46 511	49 422	21 495	4225	65 584	13
Total Density (kilometres/square km)	0.48	0.79	0.23	0.09	0.19	.0008

Source: 1997 digital map files, Alberta Environment

Figure 4.2

Grassland Natural Region and Subregions

Grassland Natural Region

The Grassland Natural Region encompasses an area of 96 221 square kilometres. A total of 830 square kilometres is under some form of protected areas legislation, either provincial or federal. This region is characterized by flat to gently rolling plains with a few major hill systems, and deeply cut river valleys. Four subregions delineate the area, the Dry Mixedgrass, Mixedgrass, Northern Fescue and Foothills Fescue (Figure 4.2). Each is distinguished by small differences in climate, soils and vegetation.

Soils in the grassland natural region are Chernozems, which typically develop under grassland vegetation. The colour varies from brown in the drier regions, to dark brown and black in areas receiving more moisture. Unique landscapes of rock outcrops and badlands provide habitat for the golden eagle, rock wren, prairie falcon, ferruginous hawk, prairie rattlesnake and short-horned lizard. The region's wetlands are home to a wide variety of bird species as well as the boreal chorus frog, northern leopard frog, plains spadefoot toad and garter snakes.

Extensive narrow-leaf cottonwood forests, which are found nowhere else in Canada, occur along the Red Deer, Oldman, Belly, Waterton, St. Mary and South Saskatchewan rivers. Riparian

forests and shrublands support an abundant and diverse animal community that includes the brown thrasher, gray catbird, yellow-breasted chat, mourning dove, northern flicker, house wren, yellow warbler, deer mouse, Nuttall's cottontail and mule deer.

The Dry Mixedgrass Subregion is the warmest and driest in Alberta, and has a generally low topography. Vegetation here is dominated by both short and mid-height grass species. Most widespread are the mid-height grasses (such as spear grass, western wheatgrass, June grass, and other needle grasses) and the short grasses (such as blue grama). Tall shrub and tree growth is restricted mostly to moist coulees and river valleys.

Combined, the Mixedgrass Subregions have the highest diversity of animal species in the grassland natural region. Many species, especially those of sand dune areas in the extreme southeast corner of Alberta, occur nowhere else in the province, or only in local areas. Sandy areas support uncommon species such as the western spiderwort plant, Ord's kangaroo rat and western hognose snake. Sage grouse, lark bunting, Brewer's sparrow and pronghorn antelope prefer sagebrush communities. Characteristic species of heavily grazed areas include horned lark, McCown's longspur, chestnut-collared longspur, borrowing owl and Richardson's ground squirrel. The lightly grazed areas feature Baird's sparrow, Sprague's pipit, the sharp-tailed grouse and the upland sandpiper.

The Northern Fescue Subregion and Foothills Fescue Subregion tend to be slightly cooler and moister than the mixedgrass areas. This is reflected in the dominant grasses. The foothills fescue subregion is located along the flanks of the foothills, and includes elevations up to 1400 metres in areas such as the Porcupine Hills and Sweetgrass Hills. Vegetation cover is characterized by rough fescue, bluebunch fescue and Parry oatgrass. In the northern fescue subregion, June grass, western porcupine grass, northern wheatgrass and Hooker's oatgrass are also important. Common forbs include prairie crocus, prairie sagewort, mouse ear chickweed, wild blue flax, and three-flowered avens.

Parkland Natural Region

The Parkland Natural Region is a 62 300 square kilometre transition zone between the grasslands to the south and the forests to the north. It comprises three subregions, the Central Parkland, Foothills Parkland and Peace River Parkland (Figure 4.3), each distinguished from the other on the basis of geographic location and vegetation differences. A total of 192 square kilometres of the Parkland Natural Region is classified as protected area under some form of provincial or federal legislation. In Canada, this natural region is confined to the

Figure 4.3

Parkland Natural Region and Subregions

prairie provinces, but the largest remaining blocks of natural parkland in the world occur in Alberta (Alberta Environmental Protection 1997b).

Largest and most centrally located of the subregions, the Central Parkland Subregion forms a broad arc between the grassland and the boreal forest. The subregion features ***hummocky*** and ***ground moraines***, glacial lake beds, ***kame moraines*** and dune fields. The landscape rises and falls, with numerous lakes and permanent wetlands scattered throughout.

Vegetation is characterized by grasslands with aspen groves in the south to expansive aspen forests in the north. Aspen and balsam poplar are the main tree species with thick shrub communities of snowberry, rose, choke cherry and saskatoon. Soils are Black and Dark Brown Chernozems under the grassland/aspen grove vegetation while Dark Gray Chernozems and Luvisols lie under the aspen forests of the north.

Wildlife of the central parkland is a mixture of species from the grasslands and aspen forests. Grassland species include the upland sandpiper, Sprague's pipit and Baird's sparrow. Forest species include the woodchuck, broad-winged hawk and rose-breasted grosbeak. The Franklin's ground

squirrel and piping plover also occur in this subregion. The numerous shallow wetlands provide exceptional habitat for breeding waterfowl.

The smallest subregion, the Foothills Parkland Subregion, forms a narrow band along the eastern edge of the foothills from Calgary to the U.S. border and features rough topography with high elevations of over 1300 metres. Rapid changes in topography and climate over short distances here result in equally abrupt changes in vegetation. This is reflected in a transition from grasslands interspersed with groves of aspen, to predominantly closed aspen forests. The grassland communities consist of fescue and oat grass with a large diversity of forb and grass species. Soils are mainly Black Chernozems in forested areas with Dark Gray and Black Chernozems in the grassland areas.

Within the subregion's upland forests and shrublands are some wildlife species more common to the Rocky Mountains. These include the dusky flycatcher, MacGillivray's warbler, lazuli bunting and white-crowned sparrow. Near the southern boundary, aspen forests are home to species such as the black-headed grosbeak and blue grouse.

The Peace River Parkland Subregion, is a unique region located in the Grande Prairie, Peace River and Fort Vermilion areas, and characterized by broad, gently rolling plains with some ***uplands*** and deeply incised, steep-sided river valleys. The majority of the subregion has been cultivated and only scattered remnants of the native grassland communities remain.

The climate exhibits shorter, cooler summers and longer, colder winters with more precipitation than the other subregions. Gray and Dark Gray Luvisolic soils are found in forested areas. Vegetation consists of upland forests of aspen and white spruce, and grassland communities of sedges, intermediate oat grass, western porcupine grass, bearded wheatgrass and low goldenrod.

Wildlife species in the Peace River Parkland are similar to those found in the adjacent Boreal Forest Mixedwood Subregion. Lakes and ponds of the Peace River Parkland are important nesting areas for the rare trumpeter swan.

4.1.2 Key Issues and Initiatives

Conversion of Native Prairie

As with any ecosystem, prairie ecosystem processes have always been dynamic and variable. Since the last glaciation, these ecosystems have been affected by drought, flood, erosion and other climate forces acting on landforms, soils, flora, and fauna. Historically, flooding (in river valleys), and digging (from animals such as ground squirrels and badgers) and trampling (for example, from bison) caused the most significant disturbances of prairie soils in upland areas. Fire also occurred frequently on the prairies, ignited either by lightning or by people. Open

grasslands endured periodic heavy grazing by vast herds of bison, which in turn were prey for large predators such as the gray wolf and grizzly bear. All of these ecosystem processes have varied over time and across the province. Prairie species evolved with these natural disturbances and adapted or became dependent on them for survival (Bradley and Wallis 1996).

How have Alberta's prairie ecosystems changed since historic times? Today's prairie landscape looks very different than it did centuries ago, thanks to time and changes in the amount and type of surface disturbances. Conversion of native prairie habitats through cultivation, roads and urban areas have converted many native prairie habitats. Approximately 80 percent of Alberta's native grasslands and parklands have been transformed by these new disturbances (Alberta Prairie Conservation Forum 1995). The amount of fescue prairie remaining in Alberta is about five percent, or less, of the original area (Trottier 1992). The amount of natural parkland remaining is estimated between 5 and 15 percent (Alberta Environmental Protection 1997b). Today, native habitats for prairie species are often relatively small and highly fragmented.

Did you know?

- Native habitats occupy approximately 20 percent of the prairie landscape.
- Some of the largest blocks of native prairie occur in the dry mixedgrass subregion in the extreme southeast corner of the province.
- Fescue grasslands have been reduced to 5 percent of the original 25.5 million hectares in the prairie provinces.
- The bulk of Alberta's human population is located in these two subregions.
- Wetlands and their margins are continually threatened by human activity on the prairie. They provide essential habitat for a number of plant and animal species including several that are at risk, such as the piping plover, short-eared owl, northern leopard frog, great plains toad and western blue flag.
- About 15 percent of Alberta's vascular plant species are not native to Alberta. Many are difficult to control because they out-compete native prairie species for light, water and nutrients.

Human settlement and agriculture have made some significant and obvious changes:

- Bison no longer roam the prairie.
- Some large predators, such as the plains grizzly and prairie wolf, have disappeared.
- Woody vegetation (usually low growing shrubs) has expanded into grassland communities, the result of improved fire suppression.
- Dams and diversions influence the natural flooding of prairie rivers, affecting the riparian cottonwood forests.
- Some cultivated areas are now more prone to soil erosion.
- In much of the prairie, domesticated plants and animals have largely replaced the native flora and fauna, causing some concern about the region's biodiversity.

Species of Concern

Most of the conversion of native prairie to cropland and improved rangeland occurred at a time when there was little concern for its effects on wildlife abundance, biodiversity or ecosystem stability. Since the 1900s, the swift fox, grizzly bear, gray wolf, greater prairie chicken and the black-footed ferret have been extirpated from Alberta's prairies. The swift fox population is recovering with the help of a reintroduction program, but populations of several other species are in decline.

Today, prairie species now at risk are threatened most often by loss of habitat (their numbers usually reflect the amount of suitable habitat available) (Diamond 1993). A higher proportion of grassland and parkland species are in jeopardy relative to other natural regions in the province.

The *1996 Status of Alberta Wildlife* report classified the following wildlife species of concern for Alberta's prairie region (Alberta Environmental Protection 1996a):

In addition to these species of immediate concern, there were at least 37 other species of prairie wildlife that were not abundant, and were considered to be sensitive to further habitat loss. These species appeared on the "Yellow List" in the *1996 Status of Alberta Wildlife*. This list included three reptiles (for example, wandering garter snake), 23 birds (for example, Cooper's hawk, sharp-tailed grouse, loggerhead shrike, and grasshopper sparrow) and 11 mammals (for example, badger and long-tailed weasel).

There are many other prairie species, particularly plants and invertebrates, for which status reports have not yet been prepared. The Alberta Native Plant Council is in the process of developing a revised list of rare vascular plants for Alberta. Some of the prairie plants considered to be rare include the slender mouse-ear-cress, sand verbena, western blue flag, large-flowered paintbrush, western spiderwort and upland evening primrose (Wallis *et al.* 1987). Locations with concentrations of rare prairie plants include river valleys (for example, the Red Deer and Oldman rivers), the Middle Sand Hills adjacent to Suffield, and the extreme southeast and southwest corners of the province (Alberta Environmental Protection 1997c).

Did you Know?

- Of the 29 vertebrate species currently of concern in Alberta, 16 are largely dependent on prairie habitats.
- Of 324 species of vascular plants considered rare in Canada, about 25 percent are prairie species (Argus and Pryer 1990).
- About 20 percent of rare plants in the grassland and parkland regions are found in sandy soils and sandhill areas (Wallis 1987).

Red List

Current knowledge suggests that these species are at risk of extirpation from Alberta.

Includes the Canadian toad, great plains toad, northern leopard frog, burrowing owl, piping plover and swift fox.

Blue List

Current knowledge suggests that these species may be at risk of extirpation from Alberta.

Includes the plains spadefoot toad, prairie rattlesnake, short-horned lizard, western hognose snake, ferruginous hawk, long-billed curlew, sage grouse, short-eared owl, Sprague's pipit and Ord's kangaroo rat.

Operation Grassland Community

Initiated in 1994, Operation Grassland Community is one of the habitat programs of the Alberta Fish and Game Association. Working with landowners, industry, government and non-government organizations, the program takes an ecosystem approach to grassland conservation by profiling species at risk and minimizing landscape alterations. Farm and ranch families participating in the program report species sighted and manage a portion of their land for conservation purposes, through a voluntary habitat protection agreement. This program includes the highly successful Operation Burrowing Owl (begun in 1989) and more recent initiatives such as the Loggerhead Shrike Trail, Dinosaur Provincial Park Rattlesnake Study, and Hectares for ***Herptiles***.

Operation Grassland Community is guided by the following primary objectives:

- promote awareness of prairie species at risk in Alberta;
- protect habitat through landowner voluntary habitat program agreements;
- compile an annual Alberta population census of representative species;
- work in cooperative partnerships to plan and implement habitat projects (for example, the Loggerhead Shrike Trail); and
- work with multiple agencies on research concerning species and habitats at risk.

This is one of the few programs in Canada that strives to deliver a voluntary private stewardship, multispecies approach to wildlife and habitat conservation. Operation Grassland Communities follows the Operation Burrowing Owl's strategy of focusing on high-profile species, encouraging the public to report sightings and earning the trust and respect of landowners who agree to protect grassland habitat. Over time, additional prairie species will be added to the program to increase public awareness of the unique natural history of prairie wildlife, and its dependence on habitat.

Prairie Conservation Action Plan

The Alberta Prairie Conservation Action Plan (PCAP) is a five year (1996-2000) blueprint for action to conserve the biological diversity of grassland and parkland natural regions in Alberta. The Alberta plan is a follow-up to the original prairie-wide PCAP that was released by the governments of Alberta, Saskatchewan and Manitoba and World Wildlife Fund Canada in 1989. Saskatchewan and Manitoba are also producing provincial action plans and it is expected that common, prairie-wide conservation principles and guidelines will be adopted by all three provinces.

The Alberta PCAP was drafted by the Prairie Conservation Forum, a broad voluntary coalition of organizations with interests or jurisdiction in the grassland

and parkland landscape. The Prairie Conservation Forum includes representatives from all levels of government, agricultural and environmental interest groups, non-government organizations, industry and universities.

The Alberta PCAP's underlying principles are land conservation, community cooperation, and respect for the stewardship of local landholders. The plan's four goals aim at:

- acquiring better information about prairie ecosystems;
- ensuring government policies favour the conservation of prairie ecosystems;
- adopting land management and protective strategies across the entire landscape; and
- increased public awareness of the values and importance of prairie ecosystems (Prairie Conservation Forum 1997).

To fulfil these goals, specific objectives and actions have been identified for the next four years that will improve conservation of biodiversity within Alberta's native prairie ecosystems.

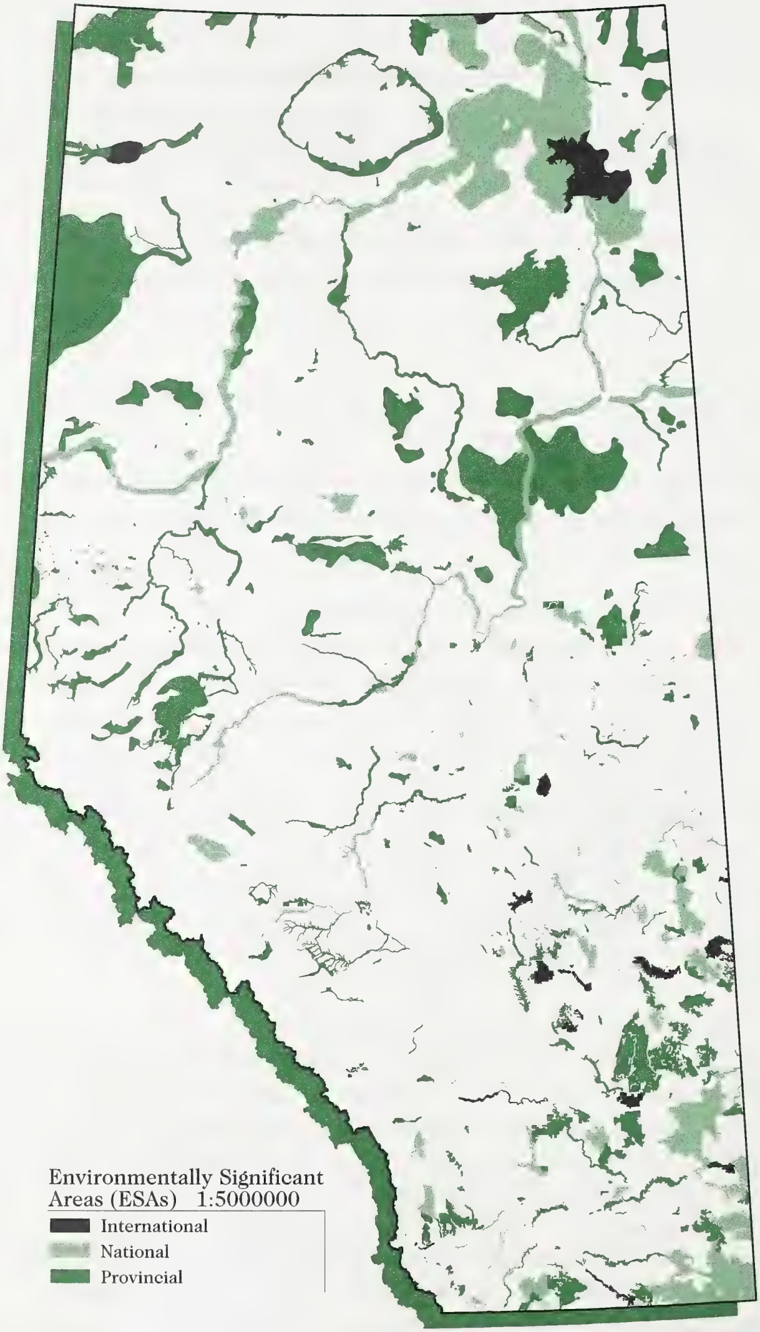
North American Waterfowl Management Plan

The Alberta North American Waterfowl Management Plan (NAWMP) is part of a larger international wetland-upland habitat conservation program. The NAWMP vision in Alberta is to restore waterfowl populations to what they averaged in the 1970s by restoring and managing aquatic and terrestrial ecosystems, integrating wildlife with sustainable economic development, and promoting conservation partnerships between public and private agencies, organizations and individuals. More than 4500 farmers on Alberta's prairie have been involved in NAWMP's programs, now one of the largest habitat conservation projects in history. So far in Alberta, the plan has protected more than 107 200 hectares of large and small wetlands, restored more than 27 100 hectares of grassland, and preserved almost 97 100 hectares of native grasslands and other habitat.

NAWMP is delivered in Alberta under the Alberta Prairie CARE (Conservation of Agriculture, Resources and the Environment) program. A voluntary initiative, Prairie CARE supports educational and collaborative projects at the farm level, such as agreements with farm managers to exchange better grazing lands for improved wetlands conservation on their property. Grazing plans are designed to enhance upland habitat for ducks and other wildlife, and improve grazing for cattle. The program also leases land to help secure prime prairie wildlife habitats. Overall, the program is designed to help farmers improve land-use while improving habitat for ducks and other wildlife. Alberta Prairie CARE is delivered on behalf of NAWMP's partners by Ducks Unlimited Canada.

Figure 4.4

Environmentally Significant Areas in Alberta



Environmentally Significant Areas inventories have not been completed for Jasper National Park

Environmentally Significant Areas

During the past ten years, an inventory was conducted of all Environmentally Significant Areas (ESAs) in Alberta. Environmentally Significant Areas are defined as landscape elements or places which are vital to the long-term maintenance of biological diversity, soil, water or other natural processes, both on-site and in a regional context (Sweetgrass Consultants 1997).

Many ESAs in the Grassland and Parkland Natural Regions are unique and important. They feature critical wildlife habitats, rare and endangered flora and fauna, unique geological or physiographic features, representative landscapes and remnants of formerly intact ecosystems. Compared to other provincial natural regions, Alberta's prairie ecosystems have a higher proportion of ESAs of international (29) or national (70) significance (Figure 4.4). The combined area of these sites is approximately 12 200 square kilometres, and includes waterbodies (such as, Beaverhill, Buffalo and Pakowki lakes) important for large numbers of migrating water birds and/or nesting piping plovers. These areas also include spectacular river valleys

(for example, Milk River Canyon) and tracts of uncultivated prairie (such as Camp Wainwright, Canadian Forces Base Suffield, Rumsey South and Sage Creek near Mannyberries).

Some ESAs are located within established protected areas, while others are simply identified on maps and in planning documents. Special land management approaches are needed to adequately protect these features.

Middle Sand Hills National Wildlife Area

Canadian Forces Base Suffield is among the largest expanses of native grassland remaining in Alberta, and indeed in Canada. The largely undisturbed grasslands and sand hills offer refuge for a wide variety of mammals, birds, reptiles, amphibians and plants, and provide sanctuary for many prairie species at risk. Used for experimental and military training, the base has some areas long recognized as ecologically fragile. One of the most sensitive is the Middle Sand Hills.

Federal legislation is underway through the Canada Wildlife Act to preserve about 458 square kilometres of the Middle Sand Hills as the Middle Sand Hills National Wildlife Area. In cooperation with Alberta Energy Company, local ranchers and residents, the Canadian Wildlife Service and the Provincial Museum of Alberta are conducting an ecological land survey to help prepare a management plan for the area. The resulting plan will effectively protect native prairie ecosystems, while accommodating military training, natural gas and oil production, and livestock grazing.

4.2 The Foothills Natural Region

4.2.1 Description

The Foothills Natural Region occurs largely in the western part of the province, east of the Rocky Mountains (Figure 4.5). Consisting of over 94 500 square kilometres, it extends from Turner Valley in the south, north along the eastern edge of the Rocky Mountains in a gradually widening belt, to the Swan Hills then west to the British Columbia border. The region also includes several outlying foothills, such as the Saddle Hills, Pelican Mountains and the Clear Hills. It consists of two subregions, the Lower Foothills and the Upper Foothills.

The eastern portion of the Lower Foothills Subregion is used for agricultural purposes, including grazing, forage and cool season crops. The cool climate of the Upper Foothills precludes most agricultural practices, but livestock do graze there in summer, primarily on valley bottoms and lower slopes. Timber harvesting is one of the Foothills Natural Region's most important land-use activities — the region contains some of Alberta's most productive forests. Oil and gas activity is also common. The region is also host to a wide variety of outdoor recreation activities, both winter and summer. At present, a total of 156 square kilometres is classified as "protected" under provincial legislation.

The Lower Foothills Subregion generally consists of rolling topography. Several eroded bedrock remnants — the Swan Hills, Pelican Mountains and the Clear Hills — are capped with pre-glacial gravels. ***Surficial materials*** are mostly of glacial origin, but bedrock outcrops of shale and sandstone occur near the mountains and along river valleys. The soils of this upland terrain are mostly Luvisols and Brunisols, with Gleyed Luvisols and Gleysols in poorly drained sites. Organic soils are common in lowlands and depressions.

The Lower Foothills has a continental climate with precipitation increasing from east to west and from south to north. Summers are cool, but winters are warmer than lower elevations on the nearby plains. Forests in this subregion reflect its transitional nature, being a mixture of white spruce, black spruce, lodgepole pine, balsam fir, aspen, white birch and balsam poplar. Black spruce forests occur on moist upland sites in the north and poorly drained peat bogs.

Wildlife of coniferous forests in this subregion include the boreal chickadee, spruce grouse, ruby-crowned kinglet, white-winged crossbill and red squirrel. Deciduous stands support ruffed grouse, warbling vireo, black-capped chickadee and Tennessee warbler. Mixedwood forests contain yellow-bellied sapsucker, rose-breasted grosbeak and purple finch. The black bear, mule deer and moose are also found here.

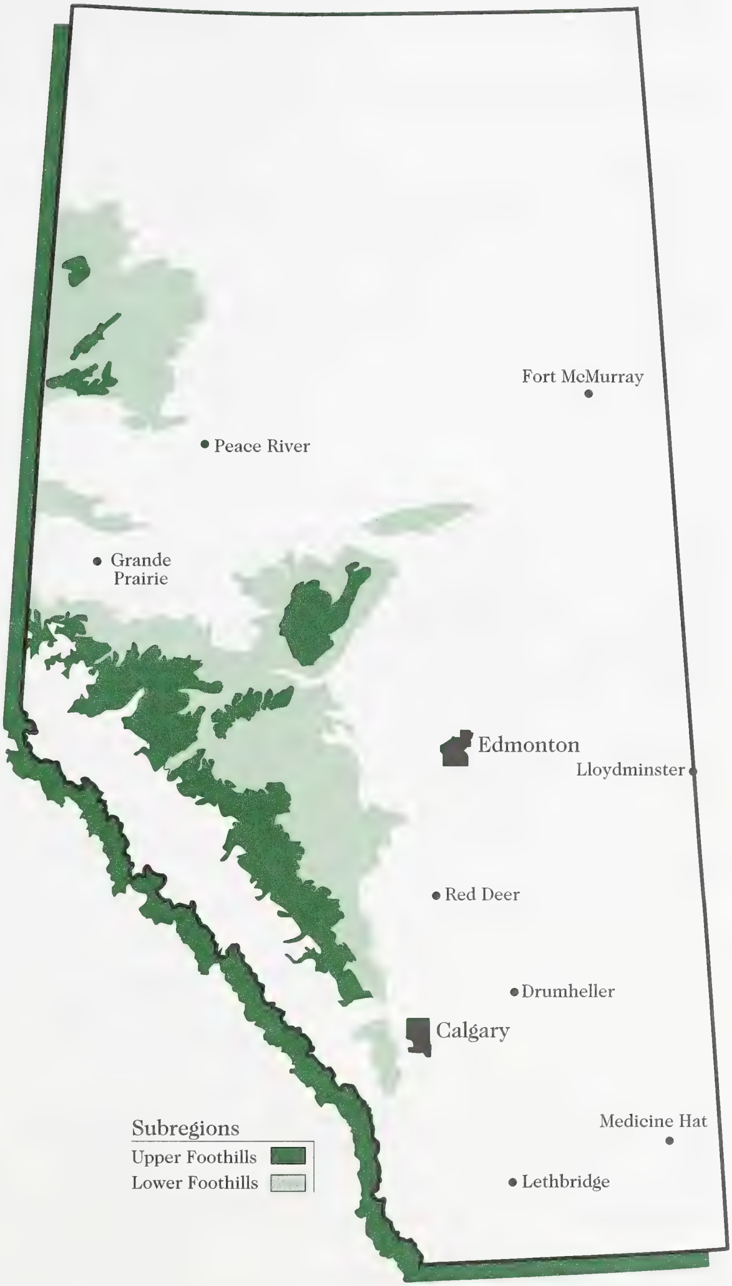
Figure 4.5

Foothills Natural Region and Subregions

The Upper Foothills Subregion occurs along the eastern edge of the Rocky Mountains, from the Bow River area in the south, north to the Grande Cache area, with isolated sections in the Swan Hills and the Clear Hills. The landscape is characterized by strongly rolling topography with frequent outcroppings of shale bedrock. Luvisol and Brunisol soils typify the uplands, and Gleysol and Organic soils are common on wetter sites.

Summers here are cool, but because the area is generally safe from cold Arctic air masses, winters are warmer than other regions. The upper foothills has the highest summer precipitation in Alberta at about 340 mm, and an average annual precipitation of 540 mm. Upland forests are nearly all coniferous and dominated by white spruce, black spruce, lodgepole pine, and occasionally subalpine fir. Lodgepole pine occupy extensive portions of the subregion's upland sites. Mosses are common on the ground in many of its plant communities.

Wildlife species are characteristic of coniferous forests in the foothills and mountains. They include birds like the pine siskin, yellow-rumped warbler, ruby-crowned kinglet, white-



crowned sparrow, and varied thrush. Larger mammals include elk, gray wolf, black bear and grizzly bear.

4.2.2 Key Issues and Initiatives

Land Uses

The Foothills Natural Region is rich in a variety of natural resources. The rangelands of the Lower Foothills subregion have traditionally been used for livestock grazing. Timber harvesting is another significant land use. Between 1966 and 1995, 75 percent of all logging on public land occurred in the foothills (Alberta Environmental Protection 1996d). Exploration and development of oil and natural gas reserves is widespread — the foothills natural region completely or partially overlies 28 oil fields and 203 gas fields (Alberta Environmental Protection 1996d). Evidence of these land uses can be found throughout the foothills.

Because of its high degree of landscape and biological diversity, the foothills region is also a favourite destination of many people for a broad range of outdoor activities. These include fishing, hunting, trapping, camping, hiking, skiing, bird watching, and off-highway vehicle use. With an abundance of coldwater streams, the foothills region provides some of the best trout fishing in Alberta. As the human population increases in the province, there will likely be increased demand on foothills recreational areas.

There has long been concern over increasing conflicts in the foothills between recreationists, conservationists and the more traditional leaseholders of public lands, such as ranchers and forestry and energy companies. Non-consumptive resource uses often conflict with consumptive uses. For example, fish-bearing streams and riparian areas are especially vulnerable to cattle-related environmental degradation (Adams and Fitch 1995). By grazing cattle on range used by deer and elk in the winter, the carrying capacity for wildlife is reduced. The forestry and energy industries, combined, require a network of access roads, seismic lines, pipelines, and other development, to accomplish their objectives. The extent and degree of these large-scale disturbances is an important factor in determining the region's management.

Careful management is necessary to ensure the widest possible current and future resource use, while managing conflicting uses. However, balancing land-use priorities in the foothills — timber harvesting, agriculture, oil and gas extraction, outdoor recreation — has always been a challenging task.

Sensitive Species — Grizzly Bear

Grizzly bears once roamed most of Alberta, with concentrations in the Rocky Mountains, foothills and major river valleys. The grizzlies of the prairies were

extirpated during the early days of exploration and settlement on the plains (Banfield 1977). Indiscriminate hunting throughout most of the early part of this century in Alberta kept grizzly numbers here low. Although grizzly bears are now better protected, the provincial population remains low, with an estimated 790 bears in 1990 (Nagy and Gunson 1990). An evaluation of the grizzly bear's status in Alberta places it on the "Blue List" — indicating that the bear may be at risk because of non-cyclical declines in its population, habitat, or its provincial distribution (Alberta Environmental Protection 1996a).

In Alberta, grizzly bears are found over a large area covering the Rocky Mountains, foothills and parts of the western boreal forest. Grizzly population densities are typically very low, and their distribution is sporadic in northern areas. Higher densities occur in Kananaskis Country, and Waterton Lakes, Banff and Jasper National Parks. About one-third of the total provincial grizzly bear population occurs in the Foothills Natural Region. Two of these populations are thought to be in a state of decline — Swan Hills and Berland-Wild Hay-Little Smoky (Nagy and Gunson 1990).

The grizzly bear is one of the most "area demanding" species found in Alberta. Nagy and Gunson (1990) report home range sizes that vary from 33 square kilometres (sub-adult female) to 2755 square kilometres (adult male). Because of its large area requirements, and their preference for largely undisturbed areas, grizzlies are often in competition with people for space. The greatest threat to grizzly bears in Alberta, particularly in the foothills, is the loss and degradation of wilderness habitat from resource extraction, recreational development, urban expansion and transportation corridors. Heavily used transportation corridors, such as the four-lane Trans-Canada highway west of Calgary, can act as complete barriers to movements by adult grizzlies (Herrero 1997). Related to this competition for space is mortality — the major factor limiting grizzly bear populations. Problem wildlife kills, and legal and illegal hunting are the most common causes of grizzly bear deaths in Alberta (Herrero 1997). Another factor in limiting the bear's population is reproductive output — one of the lowest among North American mammals. (Herrero 1997).

Did you know?

- An adult female grizzly will only produce, on average, five to seven cubs over a period of ten years.
- Although some grizzly bears will adapt to human presence, they generally need wilderness habitats largely unused by humans.

Alberta Sustainable Resource Development, in cooperation with Jasper National Park, has recently drafted a "Working Framework for Achieving Integrated Grizzly Bear Conservation." The goal is to restore or maintain a landscape that will support long-term, viable, regionally-connected populations of grizzly bears and other large carnivores. To achieve this and other goals related to sustainability, the framework involves industry, tourism and recreational interests, and protected areas. This initiative will be designed for several geographic scales over a large regional landscape. The initial framework is intended for a 10-year period with optional renewals.

Foothills Model Forest

The Model Forest Network was initiated by the Government of Canada in 1992. The Foothills Model Forest, one of 11 in Canada, is located near Hinton within the foothills and eastern slopes of the Rocky Mountains. At 2.75 million hectares (27 500 square kilometres), it is the largest model forest in the world, and includes Jasper National Park, Weldwood of Canada's Forest Management Area, Willmore Wilderness Park and other provincial land areas.

The Foothills Model Forest is managed by a Board of Directors with input from a broad range of partner groups including industry, environmental and conservation groups, educational groups, outdoor recreation organizations, and all levels of government. The land managers and major sponsors of the Foothills Model Forest organization are Alberta Sustainable Resource Development, Weldwood of Canada Limited, Jasper National Park and the Canadian Forest Service.

In its first five years, the Foothills Model Forest has created a number of unique partnerships and conducted more than $8 million in research to support the concept of sustainable forest management. This includes more than 35 projects dedicated to understanding the landbase; the collection of native fish, plants and wildlife; research into alternative forestry practices; and the social and economic issues surrounding the concept of sustainability. Scientific systems and models created by the Foothills Model Forest are now used by the program's major sponsors in building their management strategies.

The model forest program has been extended until the year 2002 in order to gain further knowledge and enable partners and sponsors to apply research results in the field. Future research will include the following:

- learning what the cumulative effect of a broad range of forest users is on the environment and the economy;
- identifying measures for ecological, economic, and social sustainability; and
- discovering how forests are influenced by natural disturbances such as fire and disease, as well as human activities.

4.3 The Rocky Mountain Natural Region

4.3.1 Description

The Rocky Mountain Natural Region comprises 46 140 square kilometres of land along the western edge of the province (Figure 4.6). It contains the most rugged topography in Alberta, formed by a major bedrock uplift along the Continental Divide. Whereas the bedrock of the Foothills Natural Region is mostly deformed sandstone and shale, the Rocky Mountain Natural Region is underlain by upthrust and folded limestone, dolomite and quartzite. The region runs from the southern end of the province at Waterton Lakes National Park, north to the Grande Cache area, and has three subregions that reflect variations in altitude and climate — montane, subalpine, and alpine.

The region's most significant land use is tourism and outdoor recreation in the large parks and protected areas. There are three national parks and several provincial parks and wilderness areas in the region and a total of 24 200 square kilometres is classified as protected area under either provincial or federal legislation. In addition to tourism and recreation values, the parks provide opportunities for heritage appreciation, ecosystem protection and conservation. The Rocky Mountains are also home to a number of rare plants and important wildlife habitats. Outside the protected areas, activities include livestock grazing, timber harvesting, coal mining, natural gas production, fishing and big game hunting.

The Montane Subregion in southern Alberta occurs on east-west ridges that extend from the foothills. Sandstone outcrops are typical of the subregion's main, southern portion. The Cypress Hills near Medicine Hat occur as a separate "island" of montane. To the north, the subregion occurs mostly along the major river valleys of the Bow, North Saskatchewan and Athabasca rivers.

The montane is characterized by warm chinook winds and is intermittently snow-free in winter. Its complex topography and climatic conditions make its soils highly variable. Chernozem, Brunisol, and Regosol soils are found under grasslands, while Brunisol and Luvisol soils lie beneath most forested areas.

The Montane landscape typically features a pattern of ***open forests*** and grasslands. Common tree species include lodgepole pine, Douglas fir, white spruce and limber pine. (Limber pine is a unique species that grows on very dry, exposed rock outcrops.) Grasslands are typically dominated by bluebunch wheatgrass, fescue grasses and oatgrasses with a large diversity of forbs. The forests of the Cypress Hills are dominated by lodgepole pine, white spruce, aspen and balsam poplar.

Figure 4.6

Rocky Mountain Natural Region and Subregions

Douglas fir and limber pine habitats are home to blue grouse, mountain chickadee, Hammond's flycatcher, Clark's nutcracker, mule deer and Columbian ground squirrel. Aspen forests commonly contain MacGillivray's warbler, the warbling vireo and the lazuli bunting. Spotted frog and long-toed salamander, found in the subregion's wetlands, are largely restricted to the Rocky Mountain natural region in Alberta. Thanks to its favourable climatic conditions, the montane is an important winter range for elk and other large ungulates.

The Subalpine Subregion occupies a band between the Montane and Alpine Subregions in the south, and the Upper Foothills and Alpine Subregions in the north. The mean summer temperature is cool, with below freezing temperatures occuring in all months and a frost-free period of less than 30 days. Winter precipitation is higher here than in any other subregion in Alberta — with more than 200 cm of snowfall annually. Soils are highly variable because of the complex topography and parent rock materials. Brunisols are common under forest cover, and Regosols occur along stream courses and on unstable slopes.

At its lower elevations, the Subalpine is characterized by ***closed forests*** of lodgepole pine, Engelmann spruce and subalpine fir, while the upper Subalpine has open forests near treeline. Whitebark pine forests occur occasionally, and subalpine larch are found south of the Bow Pass. High elevation grasslands can also be found, mostly on steep south- and south-west facing slopes, and are dominated by hairy wild rye, June grass and bearberry. Snow avalanches also create a diverse mix of shrubs and herbaceous plants.

Wildlife species of the coniferous forests include spruce grouse, gray jay, pine siskin, boreal chickadee, pine marten, snowshoe hare, deer mouse and red squirrel. Subalpine forest wildlife found almost solely in the Rocky Mountain natural region include the Steller's jay, varied thrush, Townsend's warbler, willow ptarmigan, golden-crowned sparrow and mountain caribou. American dippers and the colourful harlequin duck can be found in fast-flowing streams.

The Alpine Subregion is one of the most fragile and distinctive ecosystems in the province. Containing a mixture of vegetated areas, bare rock, snowfields and glaciers above treeline, the alpine is also the coldest subregion in Alberta. Bedrock dominates the landscape, and the patchy thin soils are poorly developed Brunisols, Gleysols or Regosols.

Alpine vegetation is a complex mosaic, responding to microclimatic variations such as slope, wind exposure, soil moisture, snow depth and time of snow melt. Black alpine sedge grows where there are deep, late-melting snowbeds . Shallow snow areas on ridge tops and other exposed sites support white mountain avens, snow willow and moss campion. Mid-range snowbed communities have dwarf shrub heath tundra dominated by heathers and grouseberry. Diverse, colourful herb meadows can be found along streams and in moist sites below melting snow banks. At the highest elevations, plant communities are mainly composed of lichens growing on rocks and shallow soils.

Many mammal species range regularly in both the Subalpine and Alpine subregions, including the Columbian ground squirrel, golden-mantled ground squirrel, chipmunk, pika, hoary marmot, grizzly bear, mountain goat and bighorn sheep. White-tailed ptarmigan, rosy finch, horned lark and American pipit restrict themselves to the Alpine during nesting season.

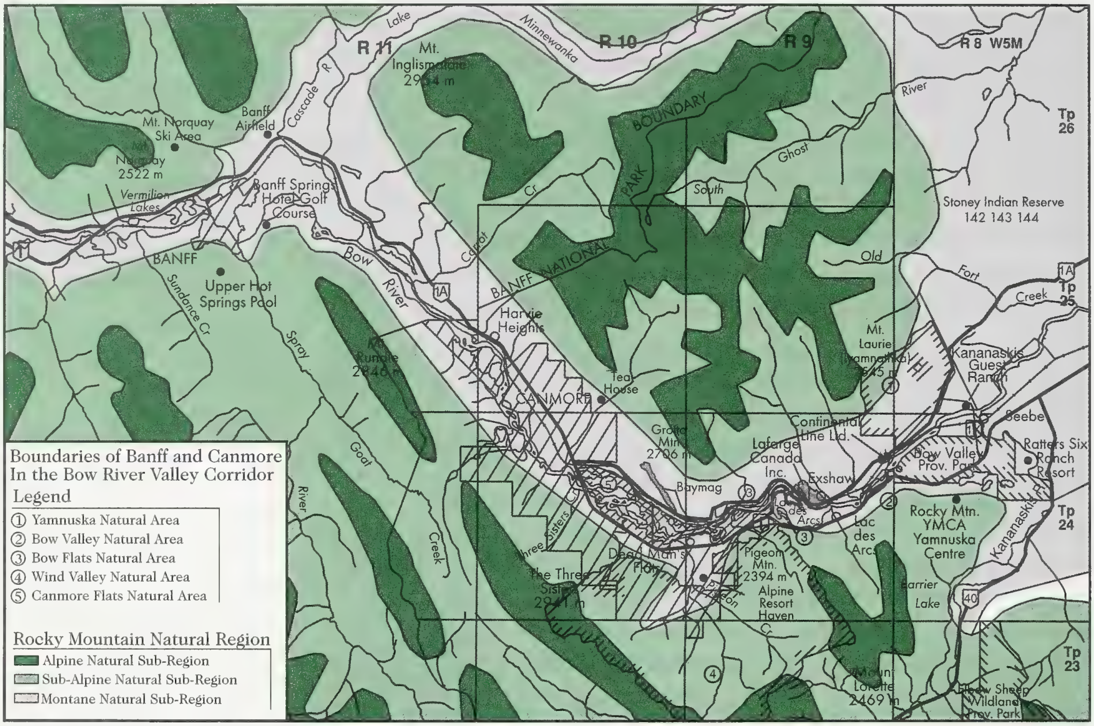
4.3.2 Key Issues and Initiatives

The Bow Corridor

The Bow Corridor, or Bow River Valley, is located in the heart of the Rocky Mountain ecosystem west of Calgary (Figure 4.7). With its relatively low elevation, and warm, dry weather — with frequent winter chinook winds — this valley adds an important element of diversity to the Rocky Mountain region.

Figure 4.7

The Bow Corridor



The valley's physical setting sustains a unique landscape of mixed grassland, aspen thickets, and forests of Douglas fir and lodgepole pine — the montane subregion.

The Bow Corridor's habitat diversity and favourable climate make it attractive to a wide variety of wildlife. Many large ungulates congregate in the Bow Corridor in winter because they can count on abundant grasses, shallow snow, and the occasional period of mild weather. Windblown ridges and sunny south-facing slopes in the Bow Valley are vital to the survival of local populations of elk (up to 1300 animals), bighorn sheep and mule deer. These species, in turn, are vital to the winter survival of wolves, coyotes and cougars that hunt them. The Bow Corridor, then, is a critical winter refuge for an important community of wildlife in this montane ecosystem. The area is also important as a vital link for large mammals moving between the Kananaskis Valley, Banff National Park, and areas to the north.

The Bow Corridor is also attractive to humans. With its mountain location, moderate climate and close proximity for a large regional urban population, the valley is undergoing a tourism and real estate boom. Along the Bow River east of Canmore, three golf courses, 1500 new hotel rooms, and 4200 housing units are expected over the next 15-20 years. Additional proposals from developers would add several more golf courses, hotels, chalets, houses and RV parks between Canmore and the Banff National Park boundary. Inside the park, new hotels and housing developments have expanded the town site, and there is a proposal to expand the Banff Springs Golf Course.

The Bow Corridor Ecosystem Advisory Group (BCEAG) was established in 1995 to deal with increasing development pressures and associated impacts within the Bow River Valley west of Calgary. An advisory body, the BCEAG is a partnership approach to ecosystem management and supports enhanced and sustainable land-use planning and decision making. The group's membership is drawn from Alberta Sustainable Resource Development; Alberta Agriculture, Food and Rural Development; the Town of Canmore; the Municipal District of Bighorn; and Parks Canada. This senior-level advisory committee coordinates the planning and monitoring of ongoing development in the Bow Corridor.

In November 1997, the BCEAG developed a comprehensive framework to better protect movement corridors for large mammals in the Bow Valley (Bow Corridor Ecosystem Advisory Group 1997). Using information from expert biologists, the framework gives clear and consistent standards for wildlife corridor design, and for acceptable development activities in and near the corridors. Very specific variables — such as corridor width, shape and size — offer useful criteria to developers and planners. These specific standards and guidelines will help reduce the impact of projects on nearby corridors, help manage the effects of human use, and determine the best way to design and connect habitat patches. Protection of a corridor network in the Bow Valley will improve wildlife movement through the Bow Valley, and enhance the maintenance of biological diversity in the larger Rocky Mountain ecosystem. The proposal addresses an important issue for residents in the long-term, and helps maintain the natural values and quality of life associated with the Bow Valley's unique natural setting.

Coal Mining

Coal has been mined in the Rocky Mountains for many years, primarily in the Crowsnest, Hinton and Grande Cache areas. Although there were many mines in the past, today there are only five coal mining operations in Alberta's mountains, with a sixth mine recently approved. These are located near Grande Cache, Cadomin and Coal Valley.

Most mountain mining operations are relatively small in comparison to the size of the Rocky Mountain natural region. In total, existing and proposed coal mines in the mountains will occupy less than 200 square kilometres, or less than one-half of one percent of the Rocky Mountains in Alberta.

Nonetheless, coal mining in this region has been controversial. One reason is the intensity and duration of activity. Open pit mines, regardless of their location, are high intensity developments that significantly alter the landscape for extended periods — usually 20 or more years. These types of disturbances carry the potential to have wide ranging effects on local watersheds, fish and wildlife, as well as outdoor recreation, tourism and other human uses. Coal mining affects

local plants and animals, and some of the Rocky Mountain species may be particularly sensitive to these human activities, such as the harlequin duck, grizzly bear, bull trout and several rare plants.

In addition to a significant alteration of the landscape, the physical setting of mountain coal mines (for instance, shallow soils and cool climate - see Section 3.3.2 for more discussion) makes reclaiming them to previous ecosystem conditions difficult. However, when done properly, reclamation can add new desirable features to the landscape. For example, open pit mining often leaves behind a series of end-pit lakes in areas where there are few naturally occurring lakes.

Intensive Recreational Use of Mountain Parks

More than one-half of the Rocky Mountain natural region is designated as park or protected area. The two largest, both in terms of area and annual visitation, are Banff and Jasper National Parks. Parks are established for a variety of goals, such as protecting ecological integrity, creating recreational opportunities, and providing economic benefits from both tourism and the direct use of park resources. The balance between these goals determines the sustainability of a parks system. Because many of Alberta's mountain national parks are significant international tourist attractions, the pressure from human development, activities and facilities in these parks is growing.

In Banff National Park, for example, the number of tourists and pace of development have continued to increase. Between 1989 and 1994, the number of person-visits to Banff rose from 3.8 million to 4.3 million annually (Department of Canadian Heritage 1995). Over the last few years, development in Banff has included shopping malls, housing projects, and hotel and motel expansions. As well, expansions have been proposed for key recreation facilities (Corbett 1994). Ski facilities have turned many mountain parks into year-round resorts. The pressure of increasing numbers of visitors and increased development has raised questions about what the parks are for — to preserve and protect ecosystems, or to serve as tourist attractions. Some park visitors and environmentalists believe that development in some parks, particularly Banff, has already surpassed the acceptable limits for recreation and tourism development in a national park (Corbett 1994).

Person-Visits

One person visiting twice equals two person-visits; two people visiting once also equals two person-visits.

A clearly defined balance is required to preserve the ecological integrity of a park while allowing sensitive use of its resources for economic and recreational benefits (Government of Canada 1996). In Banff, a federal Banff-Bow Valley study has made long-term recommendations to address development and protection issues

within Banff National Park's boundaries. Some of the study's suggestions for managing the large number of visitors to Alberta's mountain parks include supplying abundant pre-trip information, ensuring quality road transportation networks, scheduling access, limiting use, hardening the trails in sensitive areas, training visitors, and policing.

4.4 Boreal Forest Natural Region

4.4.1 Description

The Boreal Forest Natural Region is the largest natural region in Alberta, covering more than 346 000 square kilometres in the northern half of the province (Figure 4.8). The region consists of broad lowland plains and discontinuous hill systems, with bedrock buried beneath deep glacial deposits. An important characteristic of the Boreal Forest Natural Region are its extensive wetlands, such as bogs, fens and marshes. The boreal forest is diverse and is divided into six subregions based on vegetation, geology and landform features.

Land use activities in the Boreal Forest Natural Region are diverse and widespread. They include timber harvesting, conventional oil and natural gas development, oil sands mining (in the Fort McMurray area), coal mining, agriculture, peat harvesting, hunting, fishing, recreation and tourism. Agriculture, mainly crops such as cereals, oilseeds, and grass seed, as well as some livestock, are raised here in the northern region. In the past, conversion of forest to agricultural use was significant, especially along the agriculture-forest fringe. This practice has decreased substantially and is now more or less balanced by the reverse process of converting marginal agricultural lands to forest.

A total of 35 661 square kilometres (10.3 percent) is classified as protected area under some form of provincial or federal legislation.

The Dry Mixedwood Subregion is characterized by terrain varying from the level to the undulating. Surficial deposits are mostly ground and *hummocky moraines* with some areas of sand dunes and sandy outwash plains. Soils are Gray and Dark Gray Luvisols in well-drained upland areas with Brunisols in sandy uplands, and Organic and Gleysolic soils on low-lying sites.

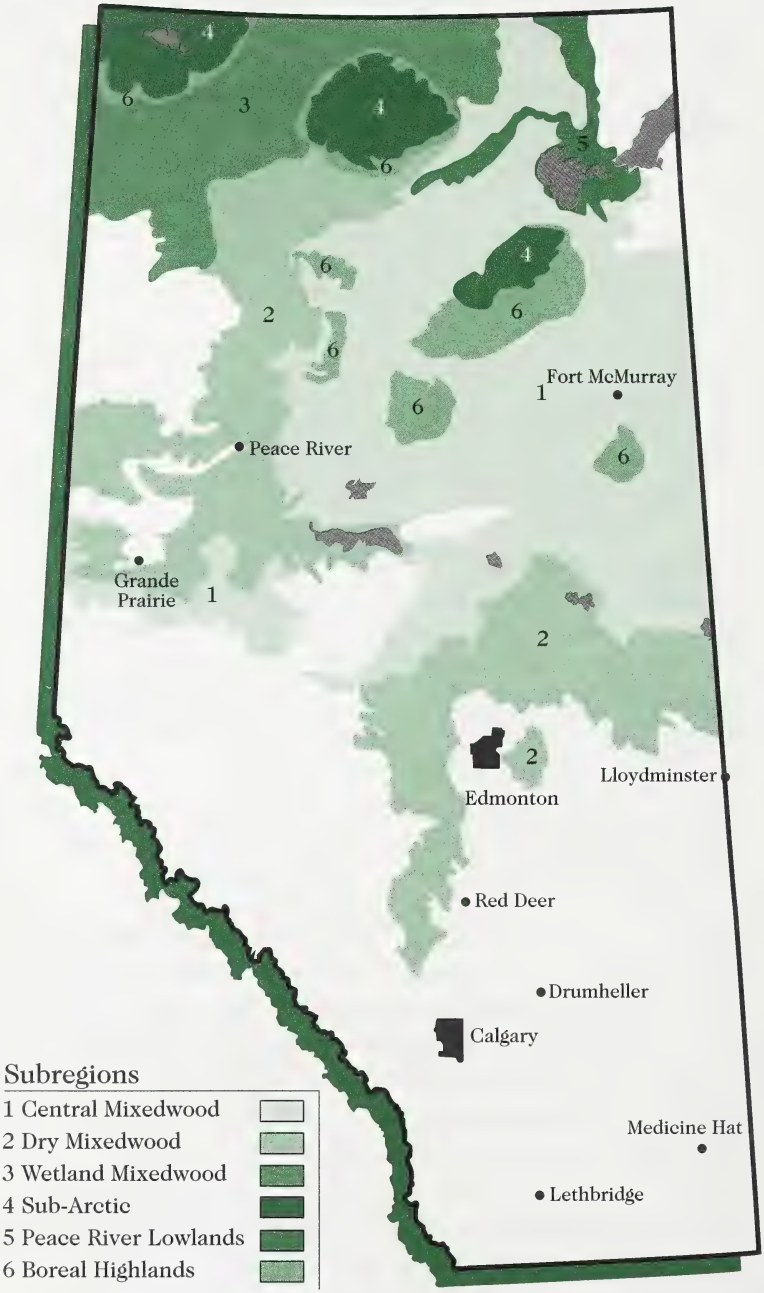
Figure 4.8

Boreal Forest Natural Region and Subregions

The vegetation reflects the subregion's status as a transition zone between the Central Parkland and Central Mixedwood subregions. Aspen, balsam poplar, white spruce and jack pine are tree species commonly found here. Mixed stands of aspen and white spruce, with a varied understory, are widespread throughout, while pure deciduous stands are common in the subregion's southern part. Characteristic wildlife species of deciduous forests include the least flycatcher, house wren, northern oriole and rose-breasted grosbeak. Species of mixedwood forests are the yellow-bellied sapsucker, Swainson's thrush, solitary vireo, magnolia warbler, white-throated sparrow, pileated woodpecker and northern goshawk. Typical mammals are the white-tailed deer, beaver, snowshoe hare and ermine.

The Central Mixedwood Subregion is the largest subregion in Alberta and includes much of the central and southeastern part of the Boreal Forest. It is an area of relatively level topography with soils similar to the Dry Mixedwood Subregion. Overall, the climate is moister and cooler than the dry mixedwood.

Deciduous and mixedwood forest communities offer a lush mixture of habitat that promotes an abundance of wildlife. Aspen, balsam poplar,



white spruce, balsam fir and white birch are common trees here. The succession of deciduous to coniferous species is frequently disturbed by forest fires. The wildlife of this subregion is the most diverse of the Boreal Forest Natural Region, thanks to good habitat (such as the mixedwoods and shrublands) interspersed with bogs, ponds, streams and lakes. Some of the wildlife species of this subregion include the great gray owl, boreal owl, gray jay, red-breasted nuthatch, pine siskin, red and white-winged crossbills, boreal chickadee, red squirrel, beaver, moose, snowshoe hare, least chipmunk, black bear, ermine, gray wolf and Canada lynx. Fisher, wolverine, river otter and woodland caribou are also found in some areas.

The Wetland Mixedwood Subregion has a nearly level topography. Its surface materials are composed of glacial lake sediments, topped by extensive organic deposits. Typical soils are Organic and Gleysolic soils in wetter areas, and Gray Luvisols on upland sites. The climate is colder than the Central Mixedwood Subregion. Snow cover lasts an average of 185 days per year, one of the longest snow-cover periods in Alberta.

Vegetation is similar to that of the Central Mixedwood Subregion, but with more peatlands, willow-sedge wetland and upland black spruce forests. Wildlife in the wetland mixedwood is sparse, both in species and numbers, because of the relative scarcity of deciduous and mixedwood forests. The extensive wetlands provide habitats for muskrats, beaver, and waterfowl, including the sandhill crane and the endangered whooping crane.

Scattered throughout the Boreal Forest Natural Region are plateaus and hill clusters that make up the Boreal Highlands Subregion. Included are portions of the Cameron Hills, Caribou Mountains, Buffalo Head Hills, Birch Mountains, Thickwood Hills, and the highlands south of Fort McMurray and around Graham and Peerless lakes.

Cool and moist conditions prevail in these higher elevations, producing permafrost in some areas. Soils are similar to those found in the Central Mixedwood Subregion, but include Cryosolic soils in permafrost areas. Mixedwood forests here tend to have high proportions of balsam poplar. Black spruce forests, pure stands of coniferous forests, and peatlands are also common and extensive. A significant species, the woodland caribou, frequents the Birch and Caribou Mountains as well as adjacent subregions.

The Peace River Lowlands Subregion consists primarily of fluvial landforms along the lower Peace, Birch and Athabasca rivers. Unique to this subregion is the Peace-Athabasca Delta in Wood Buffalo National Park — one of the largest freshwater deltas in the world. White spruce forests with large trees grow here on some terraces and islands of major rivers. Jackpine forests characterize the drier uplands; mixedwood forests of aspen, balsam poplar and white spruce grow on

Plant Succession

Following a disturbance, a plant community undergoes a long series of changes over time. Ecologists recognise many stages, called seral stages, as the plant community matures. For example, in many parts of Alberta's Boreal Forest, poplar forests are gradually replaced by spruce. Spruce trees will appear in a poplar forest, only a few at first, but more and more over time. Eventually, the spruce out-compete the poplar and a forest of spruce results.

moister sites. There is a complex mosaic of aquatic, shoreline, meadow, shrub and marsh vegetation on lowland areas, adding to their uniqueness. Much of this complexity is the result of periodic flooding and the sediments it deposits.

A rich wildlife population exists here. The subregion contains prime habitat for wood bison, American white pelican and the most northerly populations of the red-sided garter snake. The Peace-Athabasca Delta is a major nesting, moulting, staging and migration area for a wide variety of waterfowl.

The Subarctic Subregion occurs on the tops of the Birch Mountains, Caribou Mountains and the Cameron Hills. Surficial deposits are primarily glacial till or organic peat. Cool summer temperatures do not allow organic soils to warm above freezing, so discontinuous permafrost is also common. Organic and Cryosolic soils are the most common soil types, occurring throughout the subregion on wet or frozen terrain. Open forest of black spruce on peat with an understory of Labrador tea and lichen is the most common forest type. Over the years, widespread fires have created areas of heath shrub and lichen with scattered young black spruce.

The subregion's harsh environment and its limited variety of habitats are reflected in the low diversity of wildlife. Some boreal forest species are absent or have limited distributions within the subregion. Species found here that are more typical of subarctic environments include the red-throated loon, Pacific loon, red-necked phalarope, surf scoter and American tree sparrow. Common species include lesser yellowlegs, gray jay, common raven, dark-eyed junco, chipping sparrow, rusty blackbird, red squirrel, snowshoe hare, moose and black bear. Woodland caribou occur in the Birch and Caribou Mountains. The largest concentration of nesting bald eagles in Alberta is found around Bistcho Lake.

4.4.2 Key Issues and Initiatives

Maintaining the Boreal Mixedwood Forest

The boreal mixedwood forest is a mosaic of tree stands that vary in species, age, size, shape and distribution (Peterson and Peterson 1992). Trembling aspen and white spruce dominate upland sites with medium textured soils, while balsam poplar, paper birch, black spruce, jack pine, tamarack and balsam fir can be locally abundant throughout the boreal forest. Much of the diversity found in the forest can be traced to variations in soil, elevation, topography and natural disturbances such as fire, insects and disease (Attiwill 1994). Although single-species tree stands occur naturally in the boreal mixedwood forest, most stands contain both coniferous and deciduous trees.

According to Alberta's reforestation rules, the reforestation standard for an area depends on the nature of the forest being cut. For example, an area whose timber

was more than 80 percent deciduous must be reforested with deciduous trees. Similarly, an area whose timber was more than 80 percent coniferous must be reforested with coniferous trees. There is a special standard for mixedwood forests that have a more even mix of coniferous and deciduous: the new forest can be largely deciduous, but must have a merchantable portion of coniferous trees.

Maintaining the coniferous portion of the mixedwood is, in fact, the greatest challenge in maintaining the mixedwood forest. Coniferous trees are at a disadvantage in reforestation. Deciduous trees such as aspen and poplar "sucker" from their original root systems and so are quick to regrow. Conifers, on the other hand, rely only on reseeding and planting and so take longer to establish themselves. They therefore face an uphill struggle in the competition with deciduous suckers for light, water and nutrients.

There is, therefore, a "deciduous advantage" in mixedwood forest recolonization, and it means that natural succession in the forest often begins with dense stands of aspen and poplar. Only gradually do conifers invade the deciduous stands, and only after many decades are they present in numbers that once again restore the balance between deciduous and coniferous trees.

To compensate for the deciduous advantage, forestry companies usually replant and seed only conifers in the mixedwood, leaving deciduous trees to come back on their own. In some areas, newly planted conifer stands may require tending to ensure they survive the competition from the natural regrowth of aspen. This typically involves cutting or using herbicides to thin out aspen and poplar that crop up in an area, and represents a major investment in both money and effort to maintain the coniferous portion of the boreal mixedwood.

Oil Sands Mining

Bitumen extraction in the Boreal Forest natural region began in 1967, and was centred on mining the Athabasca oil sands deposits near Fort McMurray. Since then, more than 70 percent of Alberta's bitumen production has come from two surface mining operations — Syncrude and Suncor. The total area of current operations is approximately 150 square kilometres. With project expansions and several new operations in the initial stages of development, the amount of disturbance is predicted to increase to 1200 to 1400 square kilometres over the next 20 to 30 years. The entire disturbance will be in the Central Mixedwood subregion. Currently, a land area of about 21 000 square kilometres is under lease to petroleum companies intent on extracting bitumen reserves by a combination of surface and in situ methods. Again, these leases fall almost entirely with the Central Mixedwood ecosystem, representing almost 14 percent of its total area.

Similar to other types of surface mining, oil sands mining is an intensive activity that precludes other land uses and landscape assets for extended periods. From 20 to 50 years can pass before an oil sands mine is depleted and reclamation efforts return the landscape to the early stages of a productive mixedwood ecosystem. Other environmental issues associated with surface mining in the Central Mixedwood subregion include greenhouse gas emissions, regional air quality, water quality and impacts to surface waters, loss of habitat and biodiversity, and productivity and stability of reclaimed lands. Alberta Environment has recently initiated a Regional Sustainable Development Strategy to evaluate the potential cumulative impacts of development in this region.

Sensitive Species — Woodland Caribou

Among the deer family in North America, the woodland caribou appears to be the least able to adapt to the environmental changes of the past 100 years. Woodland caribou and their habitats are threatened in Alberta, and the *Wildlife Act* lists them as an endangered species. Approximately 3600 to 6700 caribou inhabit 113 000 square kilometres of northern and west central Alberta.

Woodland caribou inhabit the boreal forests of northern Alberta and the mixed coniferous forests and alpine regions of west central Alberta. Their winter habitat is usually pine and spruce forests, and black spruce bogs. Ground and tree lichens are woodland caribou's major food source in winter. As a result, they are most often associated with mature and old-growth coniferous forests that provide substantial quantities of lichens.

Woodland caribou populations in Alberta are constantly affected by a variety of natural and human factors, including predation, parasites and disease, habitat change, disturbance, hunting, and mortality from motor vehicle collisions. In Alberta, scientists and managers agree that wolves are the major cause of caribou mortality in natural, undisturbed habitat. However, human use of the caribou range can fragment, alter, or eliminate important habitat elements, such as winter ranges, calving areas and migration routes. The human activities that continue to have the most effect on caribou range in Alberta are timber harvesting, oil and gas exploration and development, coal mining (near Grande Cache) and the increased human access that comes with these industries. Widespread oil and gas activity increases the number of roads, pipelines, seismic lines and other access routes. These linear disturbances can harm caribou populations through increased hunting, vehicle collisions, and disrupted seasonal movements. Natural predators also use these corridors, making the caribou more vulnerable.

Throughout Alberta's woodland caribou range, the main challenge for wildlife managers is to maintain sufficient habitat for caribou and other wildlife in the face of ongoing industrial development and human activity.

Woodland Caribou Conservation Strategy

In 1994, a committee was established to develop a provincial Woodland Caribou Conservation Strategy. Consisting of stakeholders from a variety of industries, conservation groups, aboriginal groups, academia and government agencies, the committee produced a document that identified and assessed the factors that may affect caribou populations in Alberta. The document also offered strategies based on those factors and recommended management activities to make the strategies effective.

Currently, three regional caribou management committees develop management plans for caribou in the northeastern, northwestern and west central regions of Alberta. Through these committees, government and industry representatives have developed guidelines for industrial activity on caribou range, and for maintaining adequate habitat for the short and long term. The committees also assess how effective the guidelines and habitat supply analysis are, determine what future research or inventory is needed, and develop cost-sharing agreements for the management of caribou and their habitat.

Did You Know?

- The winter diet of woodland caribou is usually 60-70 percent lichens.
- It takes 80-150 years for a forest community to grow adequate amounts of lichens for caribou.
- Because slow-growing lichens form the bulk of their winter diet, and snow conditions can vary from one winter to the next, woodland caribou herds need a large winter range.

This unique member of the deer family is an important component of mature coniferous forest ecosystems. Strong public support for programs maintaining wildlife and habitat in Alberta continues to help ensure that caribou are managed wisely now and in the future.

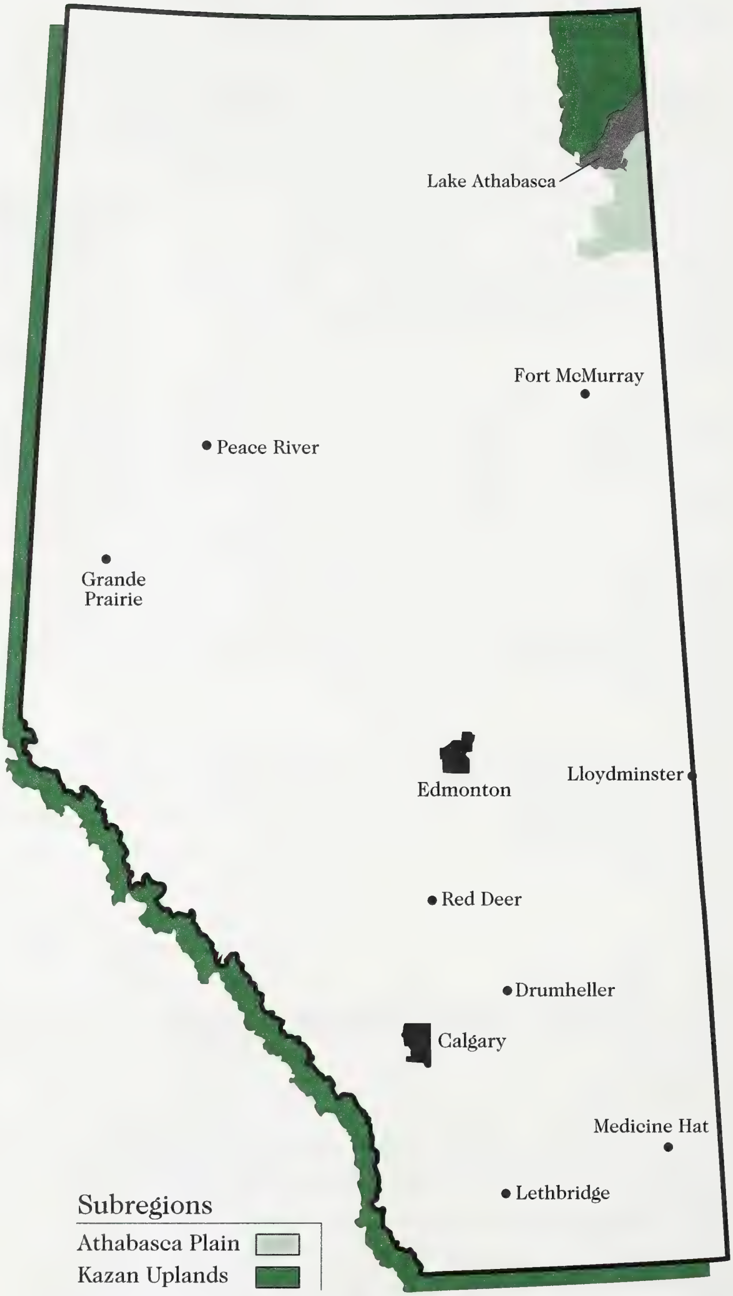
4.5 Canadian Shield Natural Region

4.5.1 Description

The Canadian Shield is the smallest natural region in the province, occupying approximately 16 000 square kilometres of land in the far northeast corner of Alberta. It contains two distinct subregions, the Kazan Upland and the Athabasca Plain (Figure 4.9). Limited access to this area has limited the use of this natural region. Uranium has been mined in the Lake Athabasca basin, but only on the Saskatchewan side. Recent geologic surveys indicate that other precious metals

Figure 4.9

Canadian Shield Natural Region and Subregions



are present. This may result in additional mining activity in the future. At present, traditional uses such as hunting, trapping, fishing and outfitting are the most important land use activities in the area. Some timber harvesting and recreational use also occurs. A total of 38 square kilometres of the region is classified as "protected" under provincial legislation.

The Athabasca Plain Subregion includes part of the north shore of Lake Athabasca and the Canadian Shield south of the lake. It is characterized by generally low relief, with extensive stretches of sandy beach along Lake Athabasca, as well as active parabolic and transverse dunes. (The dune system here is the largest in Alberta.) Numerous small lakes also dot the landscape. Upland soils are predominantly Brunisols, developed on sandy coarse-textured materials. Organic soils predominate in wet depressions, while Regosols are found in active dunes.

Jack pine forests occur on sandy uplands. Peatlands range from relatively dry bogs dominated by jack pine, black spruce, Labrador tea and reindeer lichen to wetter peatlands with black spruce, tamarack, Labrador tea and sphagnum. The shores and immediate vicinity of Lake

Athabasca contain open white spruce forests. The subregion also features a number of uncommon plant species.

Wildlife in this subregion appear to be low in number and diversity. Species found here include the red squirrel, beaver, muskrat, black bear, red fox, Canada lynx, gray wolf, moose, mink and pine marten. Birds such as the common loon, nighthawk, willow ptarmigan, Bonaparte's gull and greater yellowlegs can be seen. Sandhill cranes, Arctic terns and Caspian terns nest in this area.

The Kazan Upland Subregion is characterized by extensive outcroppings of Precambrian granite bedrock. Glacial erosion has produced highly-polished, ***striated*** and grooved rock surfaces. Rock-basin lakes are common throughout, but rivers are small, slow moving and low in number. Because of the large amount of exposed bedrock, soils are poorly developed. Where soils have developed on upland sites, Brunisols and Regosols are the most common types.

Upland vegetation is a variety of rock barrens and open forests dominated by jack pine, with some paper birch and aspen. Lichens are prevalent in the forest understory. Peatlands are usually acidic and nutrient-poor bogs dominated by black spruce, tamarack, Labrador tea, lichens and mosses. The bogs also feature discontinuous permafrost.

Characteristic wildlife species of upland forests include the common nighthawk, gray jay, common raven, boreal chickadee, red squirrel, snowshoe hare, Canada lynx and black bear. The wetlands and water bodies provide habitat for the common loon, lesser scaup, bufflehead, Bonaparte's gull, spotted sandpiper, alder flycatcher, rusty blackbird, moose, beaver and mink. Bald eagle and osprey frequent the many lakes. Also, the golden eagle and endangered peregrine falcon nest locally on cliffs in the area. The northern shrike and Pacific loon, both subarctic species, are found here during breeding season. Winter visitors include the willow ptarmigan and — occasionally — the barren ground caribou and Arctic fox.

4.5.2 Key Issues and Initiatives

Peregrine Falcon

The Kazan Upland subregion contains the highest density of breeding peregrine falcons in Alberta. The current provincial population of breeding peregrines is estimated at 49 pairs — 34 (69 percent) of these pairs are from the Canadian Shield in northeastern Alberta. Most peregrines nest on the rocky cliffs bordering the north shore of Lake Athabasca. A number of factors contribute to the high nesting density in the area. Most important are: (1) the availability of many suitable cliff nesting sites, (2) good food supply in the Peace-Athabasca Delta and surrounding area, and (3) very little human disturbance.

Dunes

Wind can move soil particles into large mounds, called dunes. Many people are familiar with sand dunes found along lakeshores. Dunes can be classified according to their shape and orientation. Parabolic dunes are crescent-shaped with the tips facing into the direction of the prevailing wind. Transverse dunes are simple linear shape at right angles to the prevailing winds.

Not long ago, the population nesting in this portion of the province were the last peregrine falcons in Alberta. By the 1970s, widespread use of the insecticide DDT had reduced the world peregrine population and in Alberta, the population was down to only three breeding pairs. All were found in the northeast corner of the province. An intensive recovery program by the Alberta government and the Canadian Wildlife Service (with some corporate sponsors), used these remaining wild falcons to raise falcon chicks born in captivity. This program was instrumental in ending the precipitous decline of the species in Alberta. Not only did the meagre population stabilize, it increased and is still doing so 25 years later. Were it not for the intensive management efforts on this remnant breeding population in the Canadian Shield, the peregrine falcon would likely have been extirpated in Alberta.

The Athabasca Dunes Ecological Reserve

The Athabasca Dunes Ecological Reserve encompasses approximately 3770 hectares in the Athabasca Plain Subregion. It was established in 1987 to protect the ecological and genetic diversity of the subregion, and the fragile nature of its landforms. With features such as the largest active dune system in Alberta, the reserve also contains a striking landscape of marshes, lakes and forested hills. Distinctive features include large areas of kame (hill or short ridge) and kettle (depression) formations of glacial origin. At over 60 metres high, the kames are some of the largest in the world. Significant plant species unique to the dune ecosystems include American dune grass, Indian tansy, horned bladderwort, sand-dune chickweed and short-tail rush.

Because of its fragile nature and sensitivity to disturbance, the Athabasca Dunes Ecological Reserve can only be travelled by foot. However, recreationists with off-highway vehicles are attracted to this area and the dunes are showing signs of vehicle use.

Mineral Mining Potential

For many years, the Canadian Shield natural region in Alberta has been studied for its potential as a source for metallic and industrial minerals. Under the recent Canada/Alberta Partnership Agreement on Mineral Development (see Section 3.3.4), several geological studies were conducted to find and analyze the market potential for minerals in the exposed Precambrian shield in northeastern Alberta.

Depending on the location, mineral mining could have a significant ecological impact on the region's rare and sensitive species. Such an operation would most surely influence the local socio-economic situation, not to mention the various forms of traditional uses in the area. Besides the area of a mine itself, improved access to the region would result in an inevitable increase in various forms of land use (hunting, fishing, off-highway vehicle use), and the level of human disturbance (e.g., road building, electricity transmission, residences, etc.).

5.0 Summary and Conclusions

Provincial Perspective

Alberta's terrestrial ecosystems are dynamic and undergo continuous change. Many agents of change are part of the natural cycle: forest fires, prairie grass fires, outbreaks of insect pests, drought, flooding, changes in climate, and so on. Other changes arise from human activity, and are primarily the result of a few widespread, major land uses. In Alberta, major land uses include crop production and livestock grazing, forestry, energy resource development, human settlement, and recreation. Data indicate that human activity on the landscape is increasing as Alberta's economy expands and the human population grows.

As discussed in previous sections, the environmental effects of these activities are many and varied. Cultivation and urbanization have transformed large areas of native grassland and parkland. Urban expansion and transportation corridors eliminate natural habitats and the opportunity for other land uses. Timber harvesting and exploration and development of oil and natural gas deposits can fragment forest habitats, and improve access to more remote areas of the province. This can be disadvantageous to wildlife species that are more sensitive to human disturbance, while benefiting other species that can tolerate some degree of human activity. The net effect of widespread, and increasing, human influence is an overall reduction in wilderness lands in the province.

The Alberta government has adopted strategies and solutions to address the negative effects of human activities, often in partnership with landowners, industries, and local governments. One key approach is called Integrated Resource Management (IRM). Through IRM, government policies, programs and activities are integrated for the best long-term benefits, while minimizing conflicts among resource users. This approach is based on cooperation and communication and includes the identification, assessment and comparison of all resources. IRM also recognizes that any specific use of a resource can affect its use and management for other purposes. In addition, IRM allows those directly affected by a decision to participate in the decision-making process before action is taken.

Other important initiatives include the following:

- As a result of the Alberta Environmentally Sustainable Agriculture Program, farmers are implementing sustainable management systems that improve soil quality, water quality, air quality and natural biodiversity.

- Programs that deliver a private stewardship, multi-species approach to fish and wildlife habitat conservation include Operation Grassland Community and the Alberta Riparian Habitat Management Program.

- Under the direction of a broad voluntary coalition of organizations, the Prairie Conservation Action Plan focuses on conserving the biological diversity of grassland and parkland natural regions in Alberta. The plan promotes land conservation, while affirming the importance of community cooperation and local stewardship.

- The Foothills Model Forest has created a number of unique partnerships with industry, local interest groups and all levels of government. The Foothills Model Forest incorporates an understanding of the landbase; plant, fish and wildlife resources; alternative forestry practices; and the social and economic issues in a large number of projects dedicated to sustainable forest management.

- Under Alberta's Forest Conservation Strategy, a multi-stakeholder steering committee consulted with more that 800 Albertans to develop a long-term vision and recommendations for our forests. The strategy goes beyond sustained yield of timber resources, and promotes the principles of ecological forest management at the ecosystem and landscape levels. The Strategy contributed significantly to a new government policy, called the Alberta Forest Legacy.

- The Special Places program is completing a network of protected areas representing the environmental diversity of the province. The priority is to fill in under-represented landscapes, or "gaps," in the existing protected areas system.

Natural Regions Perspective

Each of the six natural regions supports distinct landforms, flora, and fauna that contribute to Alberta's bountiful biodiversity and resource wealth. The following highlights the main issues and briefly discusses future changes predicted for each region.

Grassland

The Grassland Natural Region has been extensively altered by human activity and only about 25 percent of the native prairie grassland ecosystem remains. Fescue grasslands are the most altered of the grassland ecosystems. Some of the largest blocks of native prairie occur in the dry mixedgrass subregion of the southeast corner of the province, where dry conditions limit the type of agricultural use. Of the native species considered at risk in Alberta, more than one-half largely depend on prairie habitats.

Here the principal agent of change is widespread conversion of lands to other uses, particularly agricultural, transportation and urban uses. Grasslands were one of the first terrestrial ecosystems populated by early homesteaders in Alberta, and a full century of human influence is evident. The Grassland Natural Region also sits atop important deposits of oil and natural gas, and supports the second highest density of wellsites in Alberta, with the Parkland Natural Region ranking number one.

The potential for further conversion of grasslands to agricultural uses is limited. Lands most suitable for growing crops have already been cultivated, and expansion prospects, such as through additional irrigation, will eventually face practical limitations. However, with the high degree of habitat fragmentation that has already occurred, maintaining a healthy, diverse grassland community will continue to be a challenge.

Parkland

Alberta's parkland is considered the most altered natural region in the province, mostly because it has the most favourable conditions in the province for growing crops, with excellent quality soils and sufficient moisture. Combined, the Central and Foothills Parkland contain the highest proportion of the provincial population (the region includes Edmonton and Calgary), and the highest density of roads. Land conversion to agricultural and urban uses is also accompanied by a substantial amount of activity by the energy sector. Oil and gas exploration and development is intensive and widespread in this region. Wellsite densities are high relative to other natural regions — about 45 percent of all wells drilled in Alberta are in the Parkland Natural Region (Alberta Environmental Protection

1997b). This extensive human activity and resource development presents a challenge for the expansion of the region's protected areas network.

With proper land management, soil quality and favourable growing conditions in the parkland will likely not change. However, urban expansion will continue to encourage the conversion of prime agricultural land to other uses. Decreasing the agricultural landbase near urban centres may increase the demand for land in other areas, or cause producers to increase production on the existing agricultural landbase.

Foothills

The Foothills Natural Region is rich in a variety of natural resources and, although the human population is low, the amount of land used for industrial purposes is high. Alberta's most productive forests are found here and, until recently, about 75 percent of all logging in Alberta occurred in this region. The foothills also contain significant deposits of oil and natural gas, with related industrial activity most intense in the Grande Prairie, Swan Hills, Fox Creek, Drayton Valley and Rocky Mountain House areas. The high degree of landscape and biological diversity also make the foothills attractive for a broad range of outdoor recreational pursuits.

Landscape alteration and conversion from natural ecological uses is not as extensive in the foothills as it is for parkland and grassland ecosystems. Nonetheless, some combined effects of these industrial demands are evident and some sensitive wildlife species may require special management programs. As well, widespread industrial activity is sometimes in conflict with other uses such as outdoor recreation and protected areas.

What is in the foothills' future? It is estimated that approximately 25 percent of the province's known natural gas reserves are located beneath the Eastern Slopes, which include the foothills and Rocky Mountains. In an era of high demand and dwindling supplies, the pressure to further develop reserves in the foothills may intensify in the future.

Rocky Mountain

Albertans, and tourists from around the world, consider the Rocky Mountains to be one of the last great wilderness areas in the province. This ecosystem is one of the least altered, largely due to extremes in climate and topography, and the presence of some very large national parks. Human activity in the Rockies is generally limited to tourism and outdoor recreation. Nonetheless, some areas are subjected to more intensive land uses such as urban expansion, large-scale recreational developments, and coal mining.

The future ecological health of areas like the Bow Corridor will depend on careful planning to allow a balance between human developments and available natural habitats. Continued demands for metallurgical coal means that new coal mines are being developed, while some existing mines are expanding their operations. These types of projects may continue to be controversial if proposals are close to national parks or affect critical wildlife habitats.

Boreal Forest

This is the largest of Alberta's natural regions. Over the last 20 to 30 years, industrial activity has expanded rapidly, with the forest and energy industries leading the way.

Petroleum activity is most intense in the Fort McMurray, Cold Lake, Red Earth Creek and Rainbow Lake areas. However, except for Wood Buffalo National Park, almost every township in the boreal forest has wellsites. Although the overall well density is much lower than grassland and parkland regions, visible signs of intensive activity in the boreal forest are evident in the form of seismic lines and access roads. This extensive network of cutlines and roads has improved access for a wide variety of other land uses, such as hunting, fishing, off-highway vehicles and forestry. These linear developments reduce the productive forest land base and fragment the forest habitat.

Whereas the prairies experienced a period of rapid change several decades ago, Alberta's boreal forest is in the midst of experiencing its own period of rapid change. Forestry and petroleum industries have been growing significantly in this region. Most of the boreal forest landbase has been allocated for timber harvesting under Forest Management Agreements and the most intensive energy industry activity may be in the Athabasca Oil Sands deposit in the Central Mixedwood ecosystem. Approximately 21 000 square kilometres are now under lease to petroleum companies that for extraction of bitumen reserves by a combination of surface mining and in situ methods. Addressing the effects of multiple developments in this area will be very important for safeguarding regional ecosystems, biodiversity and human health.

Canadian Shield

The Alberta portion of the Canadian Shield is the smallest natural region within the province, with few roads and very little industrial activity. The human population is low and major activities are traditional ones such as fishing, hunting and trapping. This subsistence-based lifestyle is linked to the region's fish and wildlife resources. The region's lakes offer a unique fishing experience in remote wilderness settings. Under the Special Areas program, six Wildland Parks have been designated in the Canadian Shield Natural Region.

Compared to the rest of Alberta, mineral potential in the Canadian Shield is high. Recent initiatives and studies have attempted to increase the interest in developing the region's industrial and precious mineral resources. Future exploration and development could have implications for traditional uses of the land, as well as economic and social well-being of the people.

Future Outlook

Alberta possesses a rich, diverse and spectacular landscape, one that still offers many environmental options no longer available in other parts of the world. Decisions that we make now will have an impact on our ability to maintain the natural ecological functions of terrestrial ecosystems, to use our natural resources sustainably, to preserve biological diversity, and to maintain a high standard of human well-being and quality of life.

The human influence on Alberta's terrestrial environment is significant and increasing. A growing human population and an expanding economy are placing increased demands on the province's valuable resources and natural ecosystems. As we enter the 21st century, we must ensure that our natural resources and terrestrial ecosystems are managed for the greatest public benefit and in a fashion that supports Alberta's economic, social and environmental aspirations.

Ensuring a high quality of life, a healthy economy and a healthy environment is a challenge, an opportunity and a priority that must be shared by all who live in our province. The challenge is to balance opportunities for growth with the need to preserve and maintain our rich environment for future generations. Understanding the problems and achieving the solutions requires the collective actions of individuals, communities, interest groups, industry and government.

6.0 Reference

Abday, S. and D.S. Vanderwel. 1997. An introduction to water erosion control. Prepared for Alberta Agriculture, Food and Rural Development and Canada-Alberta Environmentally Sustainable Agriculture Agreement. Agdex 572-3. 12 pp.

Achuff, P.L. 1994. Natural regions, subregions and natural history themes of Alberta - a classification for protected areas management (revised edition). Report prepared for Parks Services, Alberta Environmental Protection, Edmonton. 72 pp.

Adams, B. and L. Fitch. 1995. Caring for the green zone: riparian areas and grazing management. Pamphlet prepared for Alberta Riparian Habitat Management Project.

Alberta Agriculture, Food and Rural Development and Prairie Farm Rehabilitation Administration. 1996. AG-Ventures: alternative straw use industry. Prepared in cooperation with Alberta Agriculture, Food and Rural Development, Agriculture and Agri-Food Canada, and Canada-Alberta Farm Business Management Initiative. Agdex 110/830-1.

Alberta Agriculture, Food and Rural Development. 1998. Agricultural Land Base Monitoring Study (1991-1995). Policy Secretariat. Edmonton.

Alberta Agriculture, Food and Rural Development. 1997. Annual Report: 1996-1997. Edmonton.

Alberta Agriculture, Food and Rural Development. 1995a. The Thistle Guide. Alberta Agriculture, Food and Rural Development, Soil and Crop Management Branch, Edmonton.

Alberta Agriculture, Food and Rural Development. 1995b. Agriculture statistics yearbook 1995. Alberta Agriculture, Food and Rural Development, Market Analysis and Statistics Branch, Edmonton. 169 pp.

Alberta Agriculture, Food and Rural Development. 1991. Control of Leafy Spurge with Spurge Beetles. Agdex FS643-3.

Alberta Agriculture, Food and Rural Development. No Date. Resistance of weeds to herbicides. Pamphlet prepared in cooperation with Saskatchewan Agriculture and Food and Manitoba Agriculture.

Alberta Chamber of Resources. No date. The future of oil sands heavy mineral production. Alberta Chamber of Resources, Edmonton. 14 pp.

Alberta Energy and Utilities Board. 1997a. Alberta oil and gas industry - annual statistics for 1996. Alberta Energy and Utilities Board, Calgary. Annual Statistical Series EUB ST 97-17. 113 pp.

Alberta Energy and Utilities Board. 1997b. Alberta's Reserves 1996 - crude oil, oil sands, gas, natural gas liquids, sulphur. Alberta Energy and Utilities Board. Reserve Report, Statistical Series 97-8.

Alberta Energy and Utilities Board. 1997c. Alberta coal industry - annual statistics for 1996. Alberta Energy and Utilities Board, Calgary. Annual Statistical Series AEUB 97-29.

Alberta Energy and Utilities Board. 1996a. Revised guidelines for minimizing disturbance on native prairie areas. Information Letter IL 96-9. Alberta Energy and Utilities Board, Calgary. 11 pp.

Alberta Energy and Utilities Board. 1996b. Field surveillance 1996 - Provincial summaries. Report by Alberta Energy and Utilities Board, Calgary.

Alberta Energy and Utilities Board. 1996c. 1995/96 abandonment fund annual report. Alberta Energy and Utilities Board, Calgary.

Alberta Energy and Utilities Board. 1996d. Alberta electric industry: annual statistics for 1995. Alberta Energy and Utilities Board, Calgary. Statistical Series 96-28.

Alberta Energy Resources Conservation Board. 1992. Ultimate potential and supply of natural gas in Alberta. Alberta Energy Resources Conservation Board, Calgary. Report 92-A.

Alberta Environmental Protection. 1997a. Park user statistics, 1996-97. Alberta Environmental Protection, Recreation and Protected Areas Division, Edmonton.

Alberta Environmental Protection. 1997b. The Parkland Natural Region of Alberta. Report prepared by Alberta Environmental Protection, Recreation and Protected Areas Division for the Special Places Provincial Coordinating Committee. 100 pp + maps.

Alberta Environmental Protection. 1997c. The Grassland Natural Region of Alberta. Report prepared by Alberta Environmental Protection, Recreation and Protected Areas Division for the Special Places Provincial Coordinating Committee. 229 pp + maps.

Alberta Environmental Protection. 1996a. The status of Alberta wildlife. Alberta Environmental Protection, Wildlife Management Division, Edmonton. 42 pp.

Alberta Environmental Protection. 1996b. The status of Alberta's timber supply. Alberta Environmental Protection, Forest Management Division, Edmonton. 26 pp.

Alberta Environmental Protection. 1996c. Environmental reference manual for the review of subdivisions in Alberta. Prepared by Alberta Environmental Protection, Environmental Assessment Division, Edmonton. 111pp.

Alberta Environmental Protection. 1996d. Selecting protected areas: the Foothills Natural Region of Alberta. Report prepared by Alberta Environmental Protection, Recreation and Protected Areas Division for the Special Places Provincial Coordinating Committee. 77 pp. + maps and figures.

Alberta Environmental Protection. 1994. Status of Alberta's timber supply. Canadian Council of Forest Ministers Timber Supply Conference. November 16-18, 1994. Kananaskis.

Alberta Forestry, Lands and Wildlife. 1993. Alberta's rare plants - fact sheets. Prepared for Natural and Protected Areas, Alberta Forestry, Lands and Wildlife, Edmonton.

Alberta Municipal Affairs. 1997. Official Population list 1997. Alberta Municipal Affairs, Local Government Advisory Branch, Edmonton. 11 pp.

Alberta Municipal Affairs. 1996. Land use policies. Alberta Municipal Affairs, Edmonton. 13pp.

Alberta Natural Heritage Information Centre. 1997. Summary of Alberta's flora. Unpublished summary - April 1997.

Alberta Prairie Conservation Forum. 1995. Prairie Conservation. A bulletin from the Alberta Prairie Conservation Forum. 4 pp.

Alberta Transportation and Utilities. 1997. The CANAMEX Corridor. http:\\www.tu.gov.ab.ca\pol001.htm

Alberta Treasury. 1997. Alberta Population Projections. Census Divisions 1995-2011. 249 pp.

Anderson, A-M. 1995. Overview of pesticide data for Alberta surface waters. Appendix A4. Selection of soil landscape units and study design considerations for the surface water quality monitoring program. Report prepared for CAESA Water Quality Monitoring Committee. 92 pp.

Argus, G.W. and KM.. Pryer. 1990. Rare vascular plants in Canada: our natural heritage. Canadian Museum of Nature. Ottawa. 191 pp.

Attiwill, P.M. 1994. The disturbance of forest ecosystems: the ecological basis for conservative management. Forest Ecology and Management 63:247-300.

Bamsey, C.R. 1987. A directory of primary wood-using industries in Alberta, 1986. Alberta Forest Service, Canadian Forestry Service, Edmonton. 265 pp.

Banfield, A.W.F. 1977. The mammals of Canada. Univ. of Toronto Press, Toronto. 438 pp.

Bow Corridor Ecosystem Advisory Group (BCEAG). 1997. Proposal to establish and implement protection for wildlife movement in the Bow Valley. Report prepared by Bow Corridor Ecosystem Advisory Group. 33 pp.

Bradley, C., and C. Wallis. 1996. Prairie Ecosystem Management: An Alberta Perspective. Prairie Conservation Forum, Occasional Paper No. 2. 22pp.

Brandt, J.P. 1995. Forest insect- and disease-caused impacts to timber resources in west-central Canada: 1988-1992. Canadian Forestry Service, Northern Forestry Centre, Edmonton. Information Report NOR-X-341. 28 pp.

CAESA Water Quality Committee. 1996. Impact of agriculture on Alberta's water quality. Progress Report. Prepared for Canada-Alberta Environmentally Sustainable Agriculture Agreement. 41 pp.

Canadian Forest Service. 1997a. Compendium of Canadian forestry statistics - 1996. Prepared for Canadian Council of Forest Ministers, National Forestry Database Program, Ottawa. 234 pp.

Canadian Forest Service. 1997b. The state of Canada's forests 1996-1997: learning form history. Natural Resources Canada, Canadian Forest Service, Ottawa. 126 pp.

Canadian Forest Service. 1995. Compendium of Canadian forestry statistics - 1994. Prepared for Canadian Council of Forest Ministers, National Forestry Database Program, Ottawa.

Cardinal River Coals Ltd. 1996. Cheviot Mine project application - Volume 1. Part E: Reclamation Plan. Report prepared for Alberta Energy and Utilities Board and Alberta Environmental Protection. 50 pp.

Cerezke, H.F., and W.J. Volney. 1995. Forest insect pests in the Northwest Region. Pages 59-72 In J.A. Armstrong and W.G. Ives [eds.], Forest insect pests in Canada. Canadian Forest Service, Science and Sustainable Development Directorate, Ottawa. 732 pp.

City of Calgary. 1997. Draft State of the environment report. City of Calgary, Calgary.

City of Calgary. 1995. Calgary Transportation Plan. City of Calgary, Transportation Department, Calgary.

City of Edmonton. 1997a. Edmonton's ribbon of green. Edmonton Parks and Recreation web site. http:\\www.gov.edmonton.ab.ca\parkrec\rvc

City of Edmonton. 1997b. Socio-Economic Forecast, 1997-2002 City of Edmonton. City of Edmonton Forecast Committee, Edmonton.

Clear Lake Ltd. 1995. Directory of primary wood products manufacturing in Alberta, 1995. Canadian Forest Service, Alberta Economic Development and Tourism. 86 pp.

Corbett, B. 1997. Steam assisted gravity drainage. Pages 30-36 In Alberta Chamber of Resources Directory 1997. Alberta Chamber of Resources, Edmonton.

Corbett, B. 1994. The battle for Banff. Environment Views. 17(2):20-23.

Cotton, M.M. 1995. Pesticide characteristics and a preliminary assessment of the potential environmental significance of pesticides to surface water. Report prepared for CAESA Water Quality Monitoring Committee.

Cotton, M.M, and G. Byrtus. 1995. Pesticide sales trends in Alberta. Appendix A2. Selection of soil landscape units and study design considerations for the surface water quality monitoring program. Report prepared for CAESA Water Quality Monitoring Committee. 66 pp.

Court, G.S., S. Brechtel, G. Erickson and B. Treichel. 1996. The future of the peregrine falcon (Falco peregrinus anatum) population in Alberta. Proceedings of the 4th Annual Prairie Conservation and Endangered Species Workshop. Lethbridge 1995.

Department of Canadian Heritage. 1995. State of the parks - 1994 report. Department of Canadian Heritage, Parks Canada, Ottawa.

Diamond, A.W. 1993. Integration of ecological and biodiversity concerns into sustainable land management. In: Proceedings of the International Workshop on Sustainable Land Management for the 21st century (Volume 2: plenary papers). University of Lethbridge, Lethbridge. June 20-26, 1993.

Dobson, S., and J. Thompson. 1996. Parks and protected areas: their contribution to the Alberta economy. Discussion Paper prepared for Strategic and Regional Services Division, Alberta Environmental Protection. 33 pp.

Donald, D.B., R. Bailey, R. Crosley, D. Muir, P. Shaw and J. Syrgiannis. 1993. Polychlorinated biphenyls and organochlorine pesticides in the aquatic environment along the continental divide region of Alberta and British Columbia. Environment Canada, Inland Waters Directorate, Regina.

Dorrance, M.J. [ed]. 1994. Practical crop protection: weeds, insects, diseases. Alberta Agriculture, Food and Rural Development, Edmonton.

Downes, C.M., and B.T. Collins. 1996. The Canadian bird survey, 1966-1994. Canadian Wildlife Service, Environment Canada, Ottawa. Progress Notes. No. 210.

Duchesne, L.C. 1994. Defining Canada's old-growth forests - problems and solutions. Forestry Chronicle 70(6):739-744.

Edwards, W.A.D. 1995. Mineral aggregate commodity analysis. Report prepared By Alberta Geological Survey for the Canada-Alberta MDA Project, M93-04-036. Report 1995-08. 54 pp.

Filion, F.L., E. DuWors, P. Boxall, P. Bouchard, R. Reid, P.A. Gray, A. Bath, A. Jacquemot and G. Legare. 1993. The importance of wildlife to Canadians: highlights of the 1991 survey. Environment Canada, Canadian Wildlife Service, Ottawa. 60 pp.

Filion, F.L., A. Jacquemot, E. DuWors, R. Reid, P. Boxall, P. Bouchard, P.A. Gray and A. Bath. 1994. The importance of wildlife to Canadians: the economic significance of wildlife-related recreational activities in 1991. Environment Canada, Canadian Wildlife Service, Ottawa. 46 pp.

Finch, D.M. 1991. Population ecology, habitat requirements, and conservation of neotropical migratory birds. USDA Forest Service, General Technical Report. RM-205. 26 pp.

Giancola, D. (ed.). 1997. Canada Mines Handbook. 1996-97. Southam Magazine and Information Group. 644 pp.

Government of Canada. 1996. The state of Canada's environment. Government of Canada, Ottawa.

Grumbine, R.E. 1992. Ghost bears. Exploring the biodiversity crisis. Island Press, Washington, D.C. 294 pp.

Haber, E. 1996. Invasive plants of Canada - 1996 national survey results. Draft report prepared for Biodiversity Convention Office, Environment Canada, Ottawa.

Hagan, J.M., and D.W. Johnston [eds.]. 1992. Ecology and conservation of neotropical migrant landbirds. Smithsonian Institution Press, Washington, D.C. 609 pp.

Hall, J.P. [ed.]. 1996. Forest insect and disease conditions in Canada - 1994. Natural Resource Canada, Canadian Forest Service, Ottawa. 112 pp.

Harris, L.D. 1984. The fragmented forest. Island biogeography theory and the preservation of biotic diversity. University of Chicago Press, Chicago. MI. 211 pp.

Herrero, S. 1997. Eastern Slopes Grizzly Bear Project. In Buck for Wildlife Newsletter, Alberta Conservation Association. Fall/Winter 1997.

Hobbs, R.J., and L.F. Huenneke. 1992. Disturbance, diversity and invasion: implications for conservation. Conserv. Biol. 6(3):324-337.

Hunter, M.L., Jr. 1990. Wildlife, forests and forestry: principles of managing forests for biological diversity. Prentice-Hall, Englewood Cliffs, N.J. 370 pp.

Jalkotzy, M.G., P.I Ross, and M.D. Nasserdan. 1997. The effects of linear developments on wildlife: a review of selected scientific literature. Report prepared for the Canadian Association of Petroleum Producers, Calgary. 115 pp.

Johnson, D., L. Kershaw, A. MacKinnon, J. Pojar, T. Goward and D. Vitt. 1995. Plants of the western Boreal Forest and Aspen Parkland. Lone Pine Publishing, Edmonton. 392 pp.

Korol, M. and G. Rattray. 1997. Canadian fertilizer consumption, shipments and trade 1995/96. Prepared for Agricultue and Agri-Food Canada, Farm Income Policy and Programs Directorate.

Kryzanowski, L.M. 1995. Impact of fertilizer use intensity on surface water quality. Appendix B4. Selection of soil landscape units and study design considerations for the surface water quality monitoring program. Report prepared for CAESA Water Quality Monitoring Committee.

Langenberg, C.W., and D.R. Eccles. 1996. Metallic mineral occurrence of the exposed precambrian shield in northeastern Alberta. Report prepared by Alberta Geological Survey for the Canada-Alberta Partnership Agreement on Mineral Development. Project M92-04-007. Bulletin No. 64. 71 pp.

Langenberg, C.W., H. Salat, A. Turner, and D.R. Eccles. 1993. Evaluation of the economic mineral potential in the Andrew Lake-Charles Lake area of northeastern Alberta. Report prepared by Alberta Geological Survey for the Canada-Alberta Partnership Agreement on Mineral Development. Project M92-04-07. Report 1993-08. 73 pp.

Larney, F.J., J.G.Timmermans, M.S. Bullock, S.W. McGinn and C.H. Sprout. 1997. Quantifying Wind Erosion Losses in Alberta. CAESA Soil Quality Program. Research Factsheet. CSQ07.

MacAlpine, N.D., D.F., Engstrom, J. Kirtz and S. Cook. 1997. Resources for beef industry expansion in Alberta. Prepared for Alberta Agriculture, Food and Rural Development, Edmonton. 24 pp + figures.

Moody, B.H., and P.A. Amirault. 1992. Impacts of major pests on forest growth and yield in the prairie provinces and the Northwest Territories: a literature review. Forestry Canada, Northern Forestry Centre, Edmonton. Information Report NOR-X-324. 35 pp.

Murphy, P.J. 1985. Methods for evaluating the effects of forest fire management in Alberta. Ph.D. Thesis, Department of Forestry, University of British Columbia, Vancouver.

Nagy, J.A. and J.R. Gunson. 1990. Management plan for grizzly bears in Alberta. Report prepared for Alberta Forestry, Lands and Wildlife, Edmonton. Wildlife Management Planning Series No. 2. 164 pp.

National Oil Sands Task Force. 1995. The oil sands: a new energy vision for Canada. Prepared by the National Oil Sands Task Force on Oil Sand Strategies of the Alberta Chamber of Resources, Edmonton. 58 pp.

National Round Table on the Environment and the Economy. 1997. State of the debate on the environment and the economy: the road to sustainable transportation in Canada. Ottawa. 50 pp.

Nikiforuk, A. 1994. The great Alberta timber rush. Environment Views 17(2):11-14.

Odum, E.P. 1989. Ecology and our endangered life-support systems. Sinauer Associates, Sunderland, Mass. 283 pp.

Olsen, D.N. 1992. Ethanol produced from cereal grains as an alternative transportation fuel. Department of Agricultural Engineering, University of Alberta, Edmonton

Packer, J.G. and C.E. Bradley. 1984. A checklist of the rare vascular plants in Alberta. Occasional History Paper No. 5. Provincial Museum of Alberta, Edmonton. 112 pp.

Peterson, E.B. and N.M. Peterson. 1992. Ecology, management and use of aspen and balsam polar in the prairie provinces. Canadian Forest Service, Edmonton. Special Report 1.

Prairie Conservation Forum. 1997. Alberta Prairie Conservation Action Plan. Prepared by the Prairie Conservation Forum; Lethbridge, AB. 27 pp.

Prairie Farm Rehabilitation Administration. 1990. Prairie soils: the case for conservation. Agriculture and Agri-Food Canada, Prairie Farm Rehabilitation Administration, Regina.

Rees, Wm and M. Wackernagel. 1996. Urban ecological footprints: Why cities cannot be sustainable and why they are a key to sustainability. Environmental Impact Review 16(4-6): 223-248

Robinson, S., J. Grzybowski, S. Rothstein, M. Brittingham, L. Petit and F. Thompson. 1993. Management implications of cowbird parasitism on neotropical migrant songbirds. Pages 93-102 In D. Finch and P. Stangel [eds.]. Status and management of neotropical migratory songbirds. U.S. Department of Agriculture and Forest Service, Fort Collins, CO. Technical Report RM-229. 422 pp.

Rowell, P. and D.P. Stepnisky. 1997. Status of the peregrine falcon (Falco peregrinus anatum) in Alberta. Alberta Environmental Protection, Wildlife Management Division, Edmonton. Wildlife Status Report No. 8. 23 pp.

Soil Classification Working Group. 1998. The Canadian System of Soil Classification. 3rd ed. Research Branch, Agriculture and Agri-Food Canada. Publication 646. NRC Press. Ottawa.

Sosiak, A.J., and D.O. Trew. 1996. Pine Lake restoration project: diagnostic study 1992. Alberta Environmental Protection, Water Sciences Branch, Edmonton. 120 pp.

Sprout, C., J. Timmermans and H. Vanderpluym. 1997. The effect of field shelterbelts on crop yields in Alberta. Alberta Agriculture, Food and Rural Development, Conservation and Development Branch, Edmonton. 9 pp. + appendices.

Statistics Canada. 1997a. Agricultural Profile of Alberta. Statistics Canada. Ottawa. Catalogue No. 95-180-X PB.

Statistics Canada. 1997b. Census subdivisions (municipalities) with the greatest percentage population growth, 1991 and 1996. Statistics Canada. Ottawa. Catalogue No. 93-357-XPB http:\\www.statcan.ca\english\census96\table12.htm

Statistics Canada. 1996a. Rail in Canada - 1995. Statistics Canada, Ministry of Industry, Ottawa. Catalogue No. 52-216-XPB.

Statistics Canada. 1996b. Environmental perspectives - studies and statistics. Statistics Canada, Ministry of Industry, Ottawa. Catalogue No. 11-528-XPE, No. 3.

Statistics Canada. 1996c. Road motor vehicles, registrations 1995. Statistics Canada, Ministry of Industry, Ottawa. Catalogue No. 53-219-XPB.

Strong, W.L. and K.R. Leggat. 1992. Ecoregions of Alberta. Report prepared for Land Information Services, Alberta Forestry, Lands and Wildlife, Edmonton. 59 pp. + map.

Sweetgrass Consultants Ltd. 1997. Environmentally significant areas of Alberta. Volumes 1, 2 and 3. Prepared for Alberta Environmental Protection, Resource Data Division, Edmonton.

Terborgh, J. 1989. Where have all the birds gone? Essays on the biology and conservation of birds that migrate to the American tropics. Princeton University Press, Princeton, N.J. 207 pp.

Thomas, R.G. 1994. Making connections: Alberta's neotropical migratory birds. Mono Congo Joint Venture, Calgary, Alberta. 24 pp.

Timmermans, J. and F. Larney. 1996. An introduction to wind erosion control. Prepared for Alberta Agriculture, Food and Rural Development and Canada-Alberta Environmentally Sustainable Agriculture Agreement. Agdex 572-2. 12 pp.

Trottier, G.G. 1992. Conservation of the Canadian prairie grasslands: a landowners guide. Prepared by Canadian Wildlife Service, Environment Canada, Edmonton.

Vanderpluym, H. and B. Harron. 1992. Dryland salinity investigations procedures manual. Prepared for Alberta Agriculture, Conservation and Development Branch; and Agriculture Canada, Prairie Farm Rehabilitation Administration, Edmonton.

Vitt, D.H., L.A. Halsey, M.N. Thormann, and T. Martin. 1997. Peatland inventory of Alberta - Phase One: Overview of peatland resources in the natural regions and subregions of the province. Report prepared for the Alberta Peat Task Force. 117 pp.

Wallis, C. 1987. Critical, threatened and endangered habitats in Alberta. Provincial Museum of Alberta, Edmonton. Occasional Paper No 9: 49-63.

Wallis, C., C. Bradley, M. Fairbarns and V. Loewen. 1987. The rare flora of Alberta. Volume 3. Species summary sheets. Prepared for Alberta Forestry, Lands and Wildlife, Public Lands Div.

Warren, C.L., A. Kerr, and A.M. Turner. 1989. Urbanization of rural land in Canada, 1981-1986. A State of the Environment Fact Sheet. Environment Canada, Ottawa. SOE Fact Sheet No. 89-1. 12 pp.

With, K.A., and T.O. Crist. 1995. Critical thresholds in species' responses to landscape structure. Ecology 76(8):2446-2459.

7.0 Glossary

Aquifer	An underground layer of permeable rock, sand, or gravel that stores and transmits water. The term is usually restricted to those water-bearing layers capable of yielding water in usable quantities through springs and wells.
Bioaccumulation	The process in which organisms absorb chemicals or elements from their environment through their diet or other means. Concentrations are often higher in organisms further up on the food chain.
Bryophytes	Moss-like plants (mosses, liverworts and hornworts).
Cambium layer	A thin layer of growing tissue in a tree between the bark and the wood that continually subdivides to form a new bark and wood cells.
Carnivores	Flesh-eating animals. These are secondary consumers in the food chain.
Closed forest	The taller trees are closely spaced and their upper branches intermingle to form a closed canopy. Sunlight does not reach the forest floor directly.
Coke	A hard, dry carbon material produced by heating coal to a very high temperature in the absence of air. Coke is used in the manufacture of iron and steel.
Coniferous	Cone-bearing trees with needle, or scale-like, leaves belonging to the botanical group Gymnospermae. Examples of coniferous trees are spruce, pine and fir and larch. In forestry, they are often referred to as "softwood" species.
Deciduous	Trees belonging to the botanical group Angiospermae with broad leaves that are shed annually. Examples of deciduous trees are trembling aspen, balsam poplar and white birch. In forestry, they are often referred to as "hardwood" species.
Defoliators	Animals (especially insects) that eat the leaves or needles (foliage) of shrubs and trees or cause the leaves or needles to fall off.
Eutrophication	Gradual enrichment of surface waters.
Extirpated	A species that no longer exists in the wild in Alberta, but does occur elsewhere.

Feedstock	The raw materials used in a manufacturing process. For example, logs, chips and sawdust are feedstocks for pulp- and paper-making. Natural gas is a feedstock for many petrochemicals.
Fescue	A category of grasses (Gramineae) native to parts of Alberta's prairie.
Forbs	Any herbaceous broadleaf plant that is not a grass and is not grasslike.
Herbivores	Plant-eating animals. These are primary consumers in the food chain.
Herptiles	Generic term for reptiles and amphibians.
Lipid	Any of a group of organic compounds, including the fats, oils, waxes, sterols, and triglycerides, that are oily to the touch, insoluble in water, but soluble in common organic solvents.
Merchantable	Describes timber that is economical to harvest.
Mixedwood	A forest that has both coniferous and deciduous trees.
Moraine	A pile of boulders, stones, or other debris carried and deposited by a glacier, creating ridges and mounds of different sizes and shapes. Lateral Moraines are the ridges that mark the sides of the glacier's path. Terminal Moraines are the material left behind by the farthest advance of the glacier's toe. Ground moraines form under a glacier.
Hummocky Moraine	Hilly, uneven (undulating) landscape formed by glacial depositions.
Kame	A short, steep-sided, irregular ridge, hill or mound of stratified drift deposited by glacial meltwater.
Kame moraine	A group of interconnecting kames, including, in places, kettles and eskers.
Open forest	The taller trees are widely spaced and do not form a continuous canopy. Sunlight directly reaches much of the forest floor.
Pheromones	A chemical scent that attracts specific insects or other animals.
Silviculture	The theory and practice of controlling the establishment, composition, growth and quality of forest stands.

Snag	A standing dead tree. These are used by some wildlife species for nesting or denning, especially in cavities that may be present.
Striated	Having a series of parallel lines or grooves.
Summerfallow	Cropland that is left unseeded, usually for one season, to conserve moisture in the soil and allow accumulation of nitrogen. Summerfallow fields are sometimes tilled during the summer to control the spread of weeds.
Surficial materials	In general, surficial materials are of young geologic age and make up the parent material of most soils. They include materials weathered from rock; transported materials composed of mineral, rock and organic fragments deposited by water, wind, ice, or gravity; and accumulated materials of biological origin.
Tame hay	Non-native plants that have been planted as a hay crop. An alfalfa/bromegrass mixture is the most commonly grown tame hay crop in the Black soil zone of central Alberta, where the soil and climate support a large livestock population and the province's largest concentration of tame hay.
Technology transfer	The movement of inventions and new technologies into commercial use by getting the results of research into the hands of those individuals and organizations who can put it into practical use.
Tillage	Plowing and cultivation of the soil.
Tilth	The physical condition of soil as related to its ease of tillage, fitness as a seedbed, and resistance to seedling emergence and root penetration.
Understory	Plants growing beneath the canopy of other plants. Usually refers to grasses, forbs, and low shrubs under a tree or shrub overstory.
Uplands	In contrast to wetlands, uplands are not markedly affected by groundwater or surface water. The vegetation is terrestrial in character.
Upstream oil and gas industry	A term for that part of the petroleum industry involved in exploration and development of energy reserves, but not refining or petrochemical manufacturing (the "downstream" industries).
Vascular plants	Plants possessing a well-developed system of conducting tissues (e.g. xylem and phloem) to transport water, mineral salts and foods within the plant.

8.0 Reader Feedback

Alberta State of the Environment Report - Terrestrial Ecosystems

Your response to this survey will help us improve the quality of future Alberta State of the Environment Reports!
Please complete the following feedback form and fax or mail it to:

Alberta Environment
Public Education and Outreach Branch
Main Floor, Oxbridge Place
9820 - 106 Street
Edmonton, Alberta T5K 2J6
Phone: (780) 427-6310
Fax: (780) 422-4086

1. How would you describe yourself as a reader of this report? Please check the most appropriate category.

_______ Student
_______ Teacher/Professor
_______ Government worker
_______ Private business worker (Please specify type of business: _______________)
_______ Environmentalist
_______ An interested individual
_______ Other (Please specify: _______________)

2. How did you obtain your copy?

_______ I received a copy by mail
_______ I picked up a copy from an Alberta Environment office
_______ I viewed or downloaded a copy from the Internet
_______ I viewed or borrowed a copy from a library
_______ Other (Please specify: _______________)

3. For what purpose(s) will you use this report?

_______ To learn about terrestrial ecosystems in general
_______ To assess the state of Alberta's terrestrial environment
_______ To extract specific environmental data
_______ Other (Please specify: _______________)

4. Overall, do you find this report to be:

_______ Very useful
_______ Somewhat useful
_______ Not very useful

Comments _______________

____

____

____

5. In your opinion, how well is this report organized and written?

A) This report is:
_______ Very well organized
_______ Fairly well organized
_______ Not well organized

B) The information is:
_______ Very interesting
_______ Fairly interesting
_______ Boring

C) The content is:
_______ Comprehensive
_______ Adequate
_______ Lacking in certain areas

D) The report is:
_______ Very well written
_______ Fairly well written
_______ Not well written

E) The tables and figures in the report are:
_______ Very good
_______ Adequate
_______ Not very good

Comments: ____

____

____

____

6. What did you most like and dislike about this report?

Liked: ____

____

____

Dislike: ____

____

____

7. Any other comments or suggestions for improving future reports?

____

____

____

____

____

____

Thank you for your time and cooperation!